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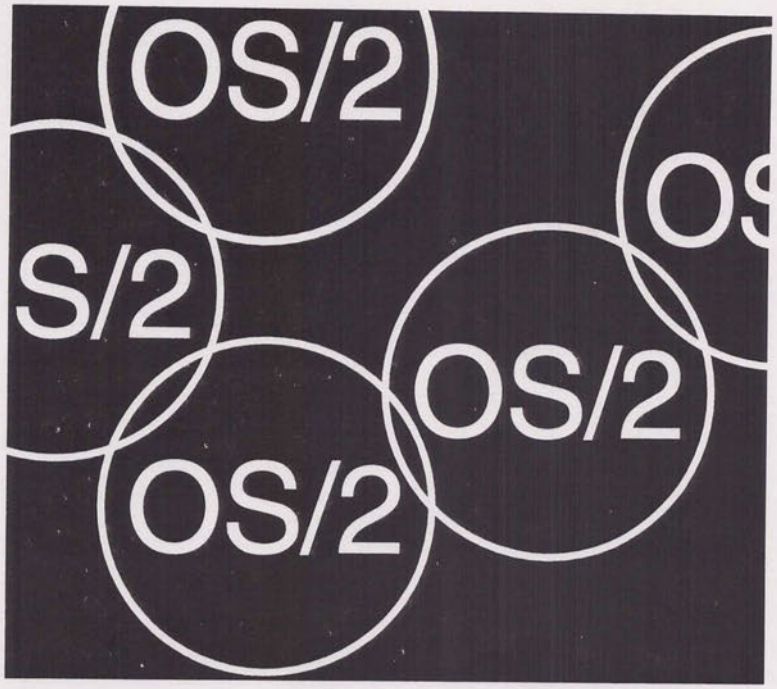
INTERNATIONAL BUSINESS MACHINES CORPORATION

Dated: April 22, 2014



OS/2 for Software Developers Version 2.x

(CN17400C/N1740)

Volume 1

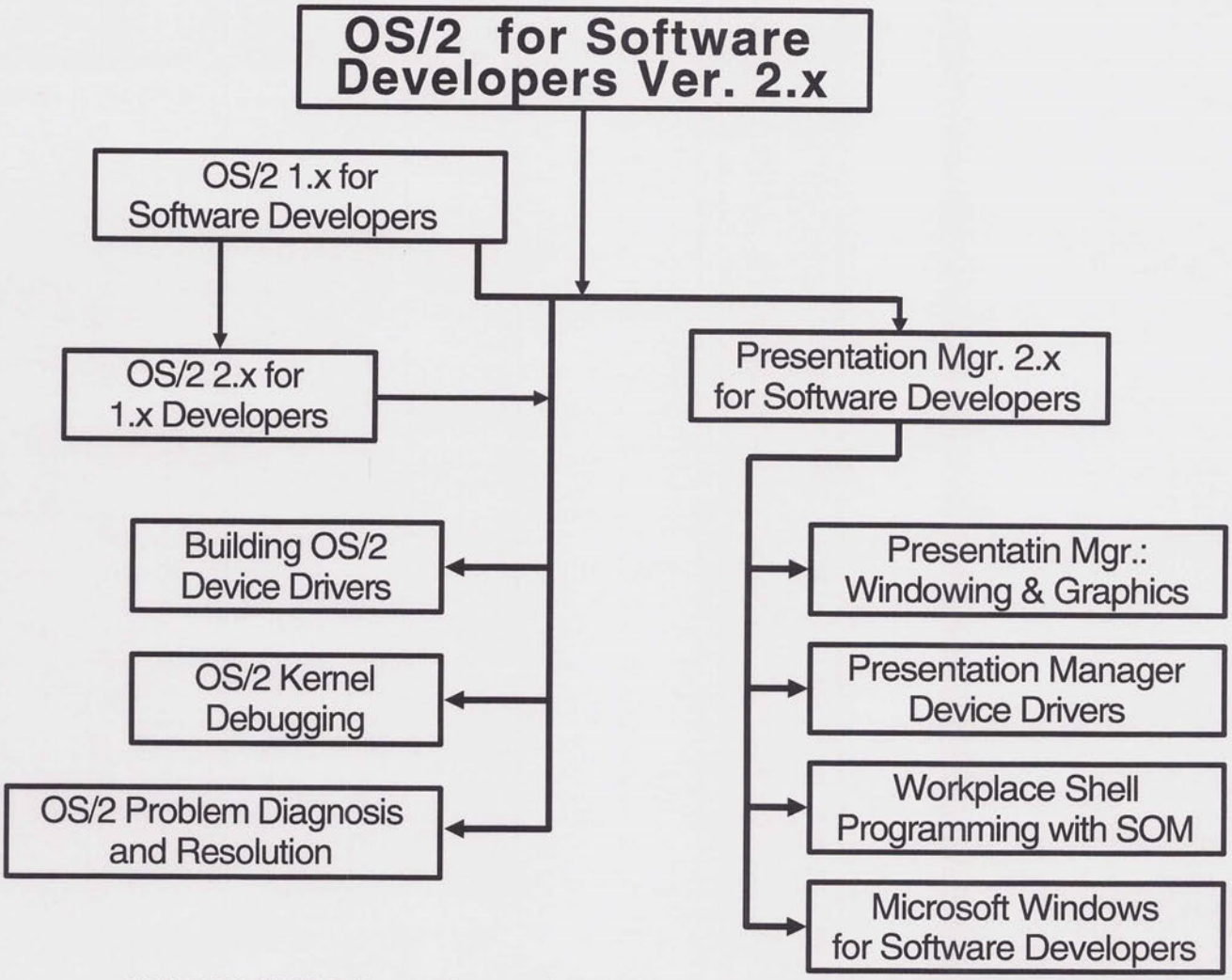
Class Workbook

NTROCVRP 940307

_HeapMem - cleans up unused/lost storage

use: view dde4clib _heapmin

Course Map



CN17410C/N1741	Microsoft Windows for Software Developers
CN17400C/N1740	OS/2 for Software Developers Ver. 2.x
CN17500C/N1750	Building OS/2 Device Drivers
CN16880C/N1688	Presentation Manager 2.x for Software Developers
CN17450C/N1745	Workplace Shell Programming with SOM
CN17440C/N1744	Presentation Manager: Windowing & Graphics
CN17420C/N1742	Presentation Manager Device Drivers
CN17430C/N1743	OS2 Problem Diagnosis and Resolution
CN17460C/N1746	OS/2 2.x for 1.x Developers
WTDMP10S	Introduction Video (SRA)
WTDMP20C	80x86 Assembler and Base Architecture
WTDMP30C	Interfacing the Personal Computer
WTDMP50C	80386 Hardware Architecture
WTDMP60C	80386/486 Assembler and Architecture
WTDMP70C	80486 Hardware Architecture

Contact Bob Rohr, Skill Dynamics (ROHR @ DALVM1)
914/742-5653 or Tie-line 770-5653

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OS/2 for Software Developers Ver. 2.x [CN17400C/N1740]

5 days Hands-on Labs

Public, Private

This course combines lectures, demonstrations and laboratory exercises to present the primary functions of the OS/2 2.0 control program. Daily exercises provide the student with experience in implementing the OS/2 2.0 Application Programming Interface.

Who Should Take This Course: Systems programmers and engineers who will use OS/2 as a base for developing hardware and software products. Persons experienced in programming OS/2 version 1.x should attend the OS/2 2.0 for OS/2 Software Developers course (WTDPS25C) for an update.

What You Are Taught: The student will be able to apply the appropriate programming tools and procedures to build OS/2 applications that implement these key features:

- OS/2 Design Goals
- Application Types
- 80386/486 Protected Mode Operation
- Memory Management
- Thread Management
- Execution Synchronization Using Semaphores
- Process Management
- Interprocess Communication Using Memory/Pipes/Queues
- File Systems
- Dynamic Link Libraries
- Session Management
- Exception Management

Prerequisites: Familiarity with the PS/2 operating and programming environment and a working knowledge of the C programming language.

Course Outline

Day 1 (A.M.)

Introduction to OS/2 [45 minutes]

- Design Goals of OS/2
- Memory Organization
- Privilege Model
- Application Programming Interface
- Multitasking Hierarchy

Pre-course Quiz [10 minutes]

OS/2 Application Types [30 minutes]

- OS/2 Mode Windowed Applications
- OS/2 Mode Full-Screen Applications
- DOS/Windows Mode Applications

Protected Mode [90 minutes]

- General Purpose and Memory Registers
- Operating Modes
- Protection Mechanisms
- Real Mode Addressing
- Protected Mode Addressing
- Memory Exceptions

Day 1 (P.M.)

Introduction to OS/2 Programming [30 minutes]

- Register-Based API
- Call-Based API
- C Program Template
- Function Prototypes
- Return Codes

Environment Strings and Command Line Arguments [45 minutes]

- Obtaining Environment and Command Line Pointers
- Searching the Environment
- Environment Strings
- Command Line
- C Program Entry State

Program Development [30 minutes]

- Programming Tools
- Header and Include Files
- Development Process
- LINK386
- NMAKE

Laboratory Exercise 1 [180 minutes]

- Introduction to the Enhanced Editor
- Writing an OS/2 Program
- IBM Presentation Debugger
- System Exceptions/Faults
- Displaying Command Line Arguments
- Experimenting with DETACH and START
- WorkFrame/2

Day 2 (A.M.)

Memory Management [70 minutes]

- OS/2 2.0 Memory Model
- Virtual Address Space
- Memory Objects
- Memory Allocation API's
- Memory Suballocation API's

Introduction to Multitasking [20 minutes]

- Serial Multitasking
- Parallel Multitasking
- Elements of Multitasking
  - Sessions
  - Processes
  - Threads

Thread Management [90 minutes]

- Thread Hierarchy
- Creating Threads
- Thread States
- Thread Priority
- Configuration Parameters
- C Programming Considerations

Day 2 (P.M.)

Laboratory Exercise 2 [180 minutes]

- Building a Single Thread OS/2 Application
- Multitasking Using Two Threads
- Thread Control
- Thread Management Using C Functions

Day 3 (A.M.)

Synchronizing with Semaphores [90 minutes]

- Uses of Semaphores
- Classes and Types of Semaphores
- Application of OS/2 Semaphores

- Event Semaphore API's
- Mutex Semaphore API's
- MuxWait Semaphore API's

OS/2 Timer Services [20 minutes]

- Synchronous Timer API's
- Asynchronous Timer API's

Process Management [70 minutes]

- Process Resources
- Creating A Process
- Process Isolation
- Testing Process Status
- Controlling Process Termination

Day 3 (P.M.)

Shared Memory Objects [40 minutes]

- Named Shared Objects
- Unnamed Shared Objects
- Shared Memory Allocation API's

Laboratory Exercise 3 [180 minutes]

- Synchronizing Threads With Event Semaphores
- Creating and Managing Processes
- Synchronizing Parent/Child Processes
- Exit Routines

Day 4 (A.M.)

File Input/Output [60 minutes]

- OS/2 File Systems
- Naming OS/2 Files
- Open/Creating Files
- Standard File Attributes
- Extended File Attributes

Interprocess Communication Using Queues [45 minutes]

- Client/Server Interprocess Communication
- Que Management API's

Dynamic Link Libraries [90 minutes]

- Static Linking
- Dynamic Linking
- Code Sharing
- Building a DLL
- Methods of Dynamic Linking
- DLL Initialization

Day 4 (P.M.)

Laboratory Exercise 4 [180 minutes]

- Load-Time Dynamic Linking
- Updating a DLL
- Run-Time Dynamic Linking
- DLL Initialization
- Pipes and Queues

Day 5 [A.M.]

Exception Management [90 minutes]

- System Exceptions
- Types of Exceptions
- Exception Handlers
- Exception Management Data Structures
- Exception Management API's

Session Management [45 minutes]

- Session Management Components
- Session Hierarchy
- Session Management API's

Interprocess Communication Using Pipes[30 minutes]

- Standard Input/Output
- Anonymous Pipes
- Named Pipes

Post-Course Quiz[30 minutes]

Day 5 (P.M.)

Laboratory Exercise Completion [open]

References:

ADG - Application Design Guide, S10G-6260
C.P.- Control Programming Reference, S10G-6263
G.S. - Getting Started, IBM Developer's Toolkit for OS/2 2.0, 10G6199
P.G.1 - Prog.Guide Vol. 1, OS/2 Tech. Lib, S10G-6264
U.G. - C Set/2 User's Guide, S10G-4444
Kogan - The Design Of OS/2, Kogan & Deitel, Addison-Wesley
Letwin - Inside OS/2, Gordon Letwin, Micorsoft Press

1. Introduction to OS/2

-1	Introduction	
-2	Design Goals - Multitasking, DevIndependence	Letwin 9
-3	Design Goals - Custom and Stable Environment	Letwin 15
-4	Design Goals - 32 Bit Environment	
-5	Design Goals - DOS/Windows Support	
-6	OS/2 2.0 Memory Organization	
-7	OS/2 Privilege Model	Kogan 37, ADG 2-11
-8	Application Programming Interface	ADG 1-29
-9	Layers of OS/2	Kogan 86
-10	OS/2 Multitasking Hierarchy	Kogan 87

2. OS/2 Applications

-1	Introduction
-2	Types of Applications
-3	OS/2 Mode Window Applications
-4	OS/2 Mode Full Screen Applications
-5	DOS /Window Mode Applications
-6	Concurrent Execution of Application Classes
-7	System Limits - 2.0 vs 1.3

3. Protected Mode

-1	Introduction	
-2	General Purpose Registers	Kogan 29,43
-3	Memory Segment Registers	Kogan 43
-4	Operating Modes	
-5	Protection Mechanisms	
-6	Real Mode Memory Addressing	
-7	Protected Mode Memory Addressing	
-8	Selector Format	
-9	Data Segment Descriptors	
-10	16-Bit Protected Mode Memory Addressing	
-11	32-Bit Protected Mode Memory Addressing	
-12	FAULT.LST	
-13	First Violation - Part 1	
-14	First Violation - Part 2	
-15	First Violation - Part 3	
-16	Second Violation	
-17	Third Violation	
-18	Fourth Violation	

4. Intro to OS/2 Programming

-1	Introduction

Introduction to OS/2

Design Goals of OS/2

Application Programming Interface

Multitasking Hierarchy

- Sessions
  - Processes
    - Threads

20NTRO01 920708

Design Goals

Multitasking With Performance/Response Equal to Single Tasking:

- ✓ Parallel multitasking through preemptive scheduling using a single CPU.
- ✓ At any time, CPU usage may be unpredictably switched to another task.

Device Independence:

- ✓ The application issues commands to a generic device.
- ✓ The device driver translates the commands to fit the characteristics of the actual hardware.
- ✓ The application does not need to know the specifics of the hardware.

20NTRO02 920708

Design Goals

Custom and Stable Execution Environment:

- ✓ Extended physical memory addressing to 4 GB.
- ✓ Virtual memory addressing to 64 TB.
- ✓ Memory protection ensures errors in one application do not corrupt any other application.
- ✓ Isolation of applications from one another and from the operating system.

20NTRO03 920708

Design Goals

- ✓ Fully exploit the capabilities of the Intel 80386 / 80486 processors.
- ✓ Provide a 32-bit programming environment that is portable to other architectures.
- ✓ Binary compatibility with the OS/2 1.x 16-bit executables.

20NTRO04 920708

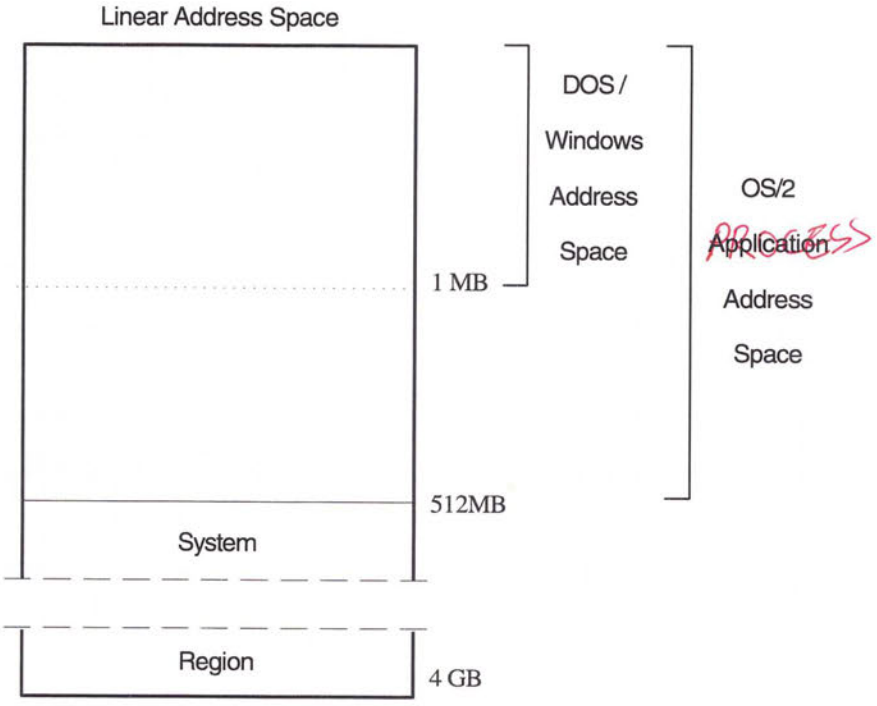
Design Goals

DOS / Windows Application Support In A Protected Environment:

- ✓ Up to 240 concurrent sessions.
- ✓ Over 630 KB of standard memory available to the application.
- ✓ Up to 32 MB of EMS, 16 MB of XMS and 512 MB of DPMI (DOS Protected Mode Interface) memory available to the application.
- ✓ Foreground or background execution in either a full screen or windowed session.

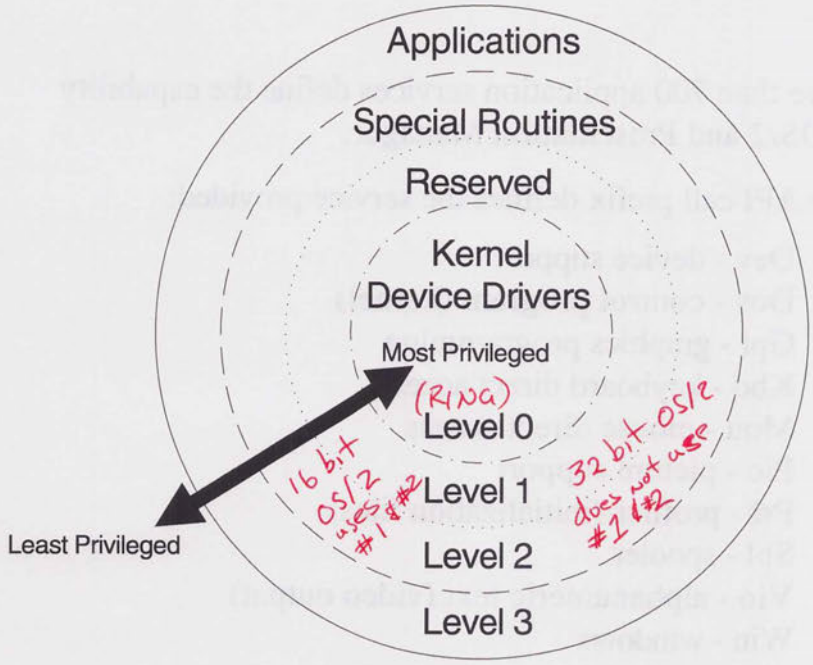
20NTRO05 920708

OS/2 2.x Memory Organization



20NTRO06 930910

OS/2 Privilege Model



20NTRO07 920708

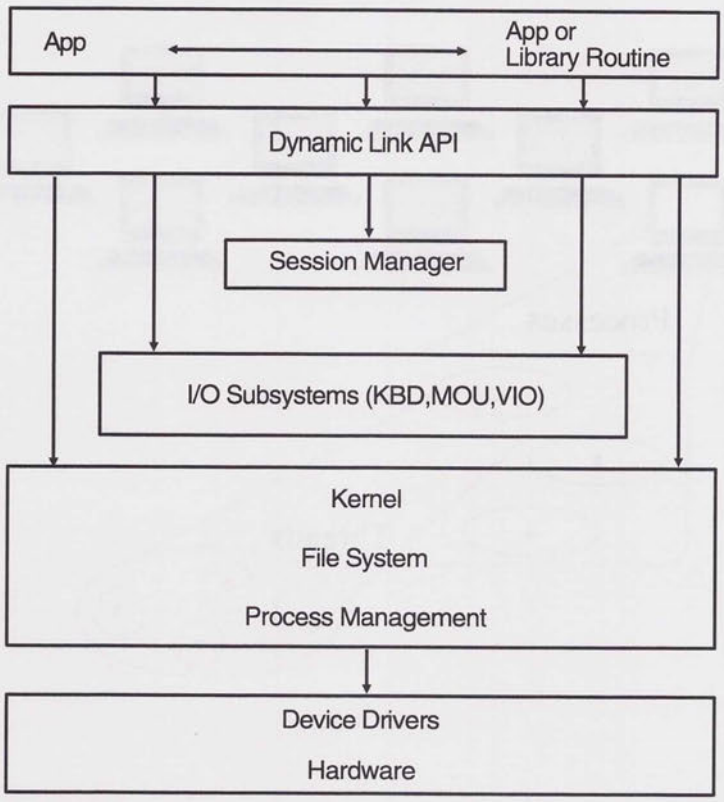
Application Programming Interface (API)

- More than 700 application services define the capability of OS/2 and Presentation Manager.
- The API call prefix defines the service provided:

  Dev - device support
  Dos - control program (kernel)
  Gpi - graphics programming
  Kbd - keyboard direct access
  Mou - mouse direct access
  Pic - picture support
  Prf - profiles (initialization files)
  Spl - spooler
  Vio - alphanumeric text (video output)
  Win - windows

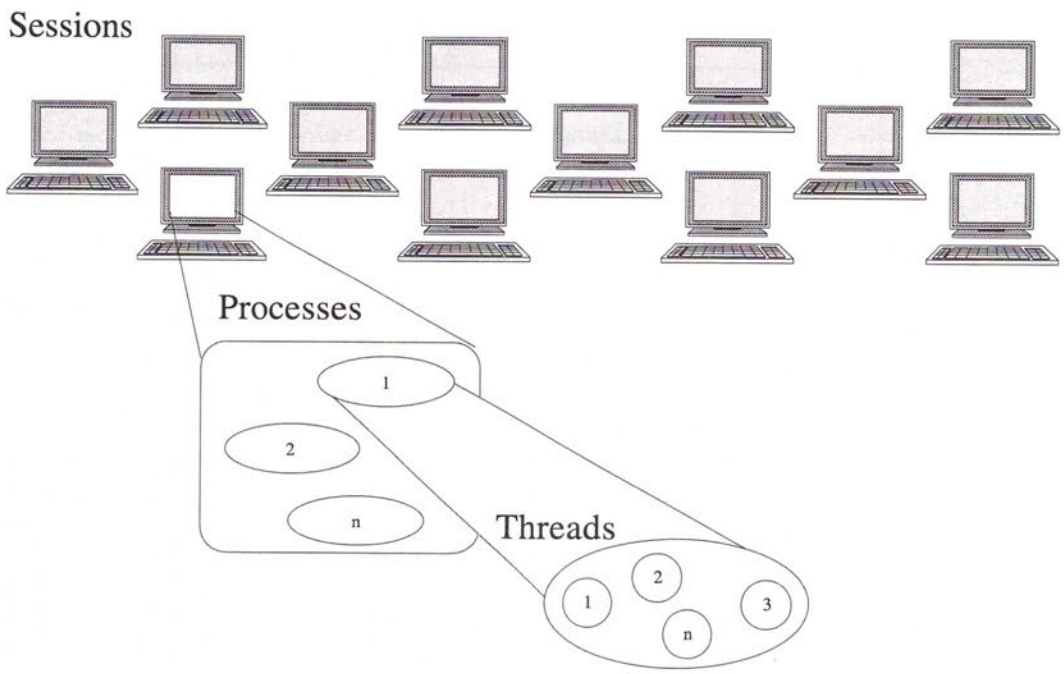
2ONTRO08 920708

Layers of OS/2



20NTRO09 920708

OS/2 Multitasking Hierarchy



20NTRO10 920708

OS/2 Applications

OS/2 Mode Applications

DOS Mode Applications

20APPS01 920709

Types of Applications

- OS/2 Mode Windowed Applications:
  - Each applications runs in a separate session
  - May share the display with other windowed applications.
  - Applications multitask.

- OS/2 Mode Full-Screen Applications:
  - Applications do not share the display with other applications.
  - Applications multitask.

- DOS / Window Mode Applications:
  - OS/2 emulates PC-DOS.
  - MOST applications will run the same as under PC-DOS.
  - Applications may execute in a window or full screen.
  - Applications multitask.

20APPS02 920709

OS/2 Mode Windowed Applications

- Presentation Manager Applications:

  Creates one or more windows to present functions to the user.
  May generate full graphics.
  Should adhere to the SAA Common User Access definition.
  Is aware that the system is being shared with other applications.
  Applications multitask.

- Text-Windowed Applications:

  Do not explicitly create windows.
  OS/2 provides a default window for execution.
  Applications multitask.

02APPS03 920709

OS/2 Mode Full-Screen Applications

- ✓ Do not share the display with other applications.
- ✓ Each application runs in its own full-screen session.
- ✓ Applications multitask.

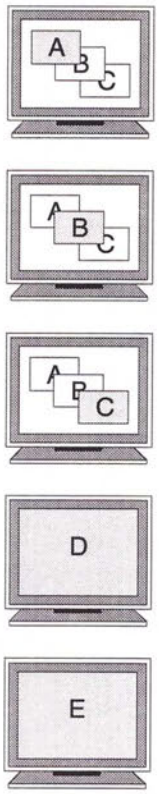
20APPS04 920709

DOS / Window Mode Applications

- ⊘ Applications originally developed for PC-DOS that adhere to the PC-DOS specification.
- ⊘ Window applications written to the 3.1 sepcifications.
- ⊘ Applications execute in a window or full screen.

20APPS05 931101

Concurrent Execution of Application Classes



System Limits - 2.x vs 1.3

32 bit 16 bit

	2.0		1.3	
	Sys	Usr	Sys	Usr
Sessions				
Full-Screen	255	255	16	12
Graphic-Window (PM)	255	252	16	14
Text-Window	255	252	16	16
MVDM (DOS)	255	252	1	1
Processes	4096	4065	511	504
Threads	4095	4065	512	483
Threads per Process	4095	4065	54	54
Open File Handles - system wide	64K		64K	
Global Semaphores - system wide	64000	64000	512	512
User signals per process			3	
Minimum stack for Thread		8K		4K
Timers per Thread			1	
Process Address Space		512M		512M

20APPS07 930910

Notes

Protected Mode

Register Set

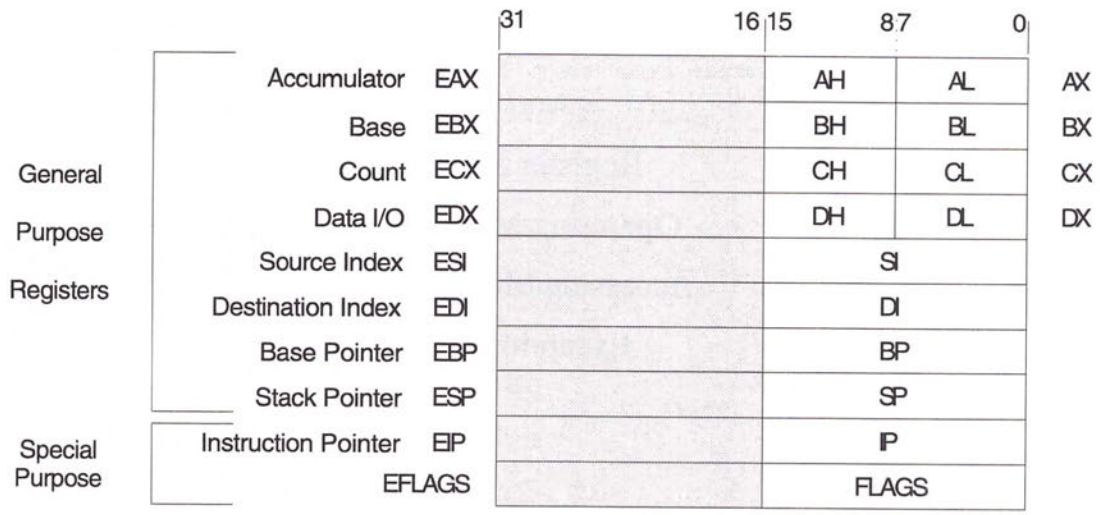
Operating Modes

Accessing Memory

Exceptions

20PMOD01 920709

General Purpose Registers



Available in the 80386/486

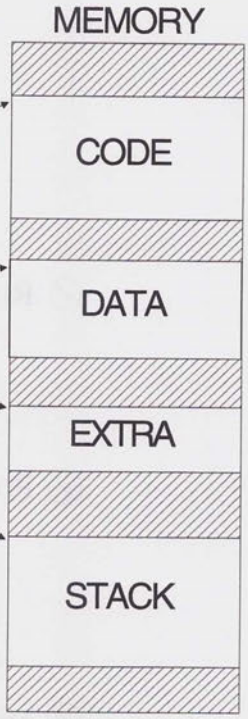
20PMOD02 920709

– Error Codes Return to the Accumulator (EAX)

Memory Segment Registers

- The 8088/80286 have 4 Segment Registers:

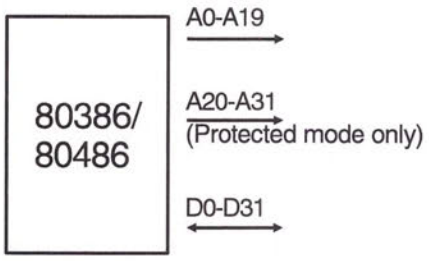
CODE SEGMENT	(CS)
DATA SEGMENT	(DS)
EXTRA SEGMENT	(ES)
STACK SEGMENT	(SS)



- These Segment Registers point to the beginning of the 4 currently addressable memory segments.
- Additional segments registers, FS and GS, are available in the 80386/486.

20PMOD03 920709

Operating Modes



- Real Mode:
  - 1MB physical address space
  - Runs like a fast 8086
  - Default power-on mode
- Protected Mode:
  - 4 GB physical memory
  - Memory Protection
  - Hardware Task Switches
  - 64 Terabyte Per Task Virtual Memory Support
- Virtual 8086 Protected Mode
  - Supports execution of 8086/8088 programs in a protected mode environment.

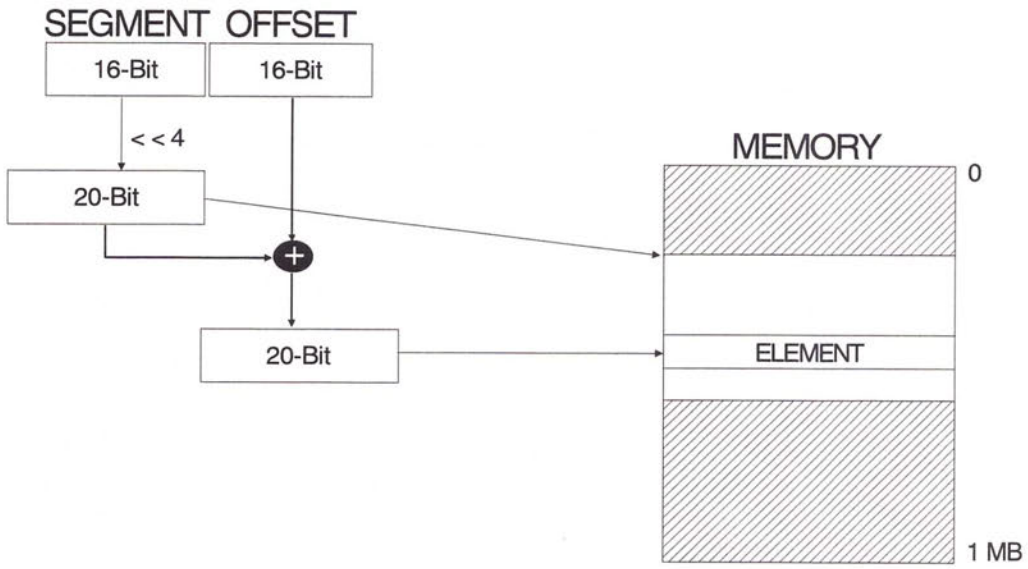
20PMOD04 920709

Protection Mechanisms

- Protects the user from programming errors:
  - Out of range accesses
  - Incorrect I/O
  - Overlaying interrupt vectors
- Protects processes from other processes:
  - Processes are isolated
- Protects the operating system from the user:
  - Multiple privilege levels

20PMOD11 930628

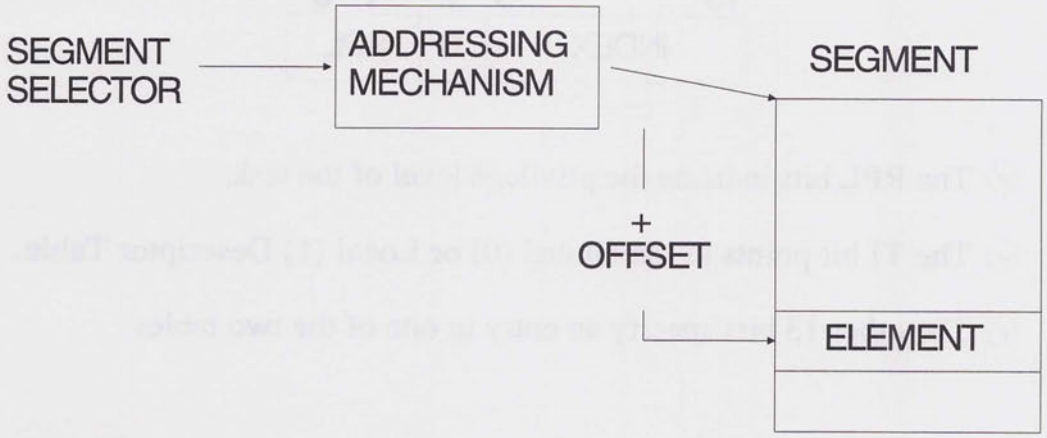
Real Mode Memory Addressing



- There is a direct relationship between the segment register value and the physical memory address.
- [SEGMENT * 16] + OFFSET = 20 bit physical address

20PMOD05 930719

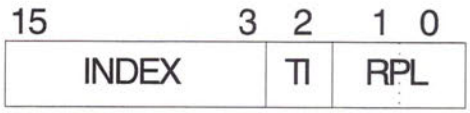
Protected Mode Memory Addressing



- ✓ The address = Selector : Offset.
- ✓ The Selector does not point directly to memory.
- ✓ Selector : Offset can refer to an element not currently present in physical memory (logical address).

20PMOD06 920709

Selector Format

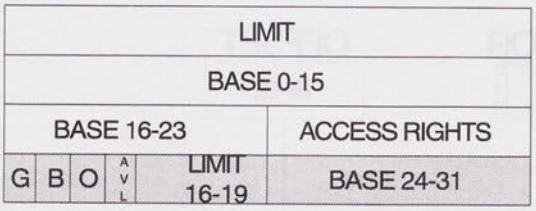


- ✓ The RPL bits indicate the privilege level of the task.
- ✓ The TI bit points to the Global (0) or Local (1) Descriptor Table.
- ✓ The other 13 bits specify an entry in one of the two tables.

$$2^{32} \text{ BYTES/SEGMENT} \times 2^{14} \text{ SEGMENTS} = 2^{46} \text{ BYTES}$$

20PMOD07 920709

Data Segment Descriptors

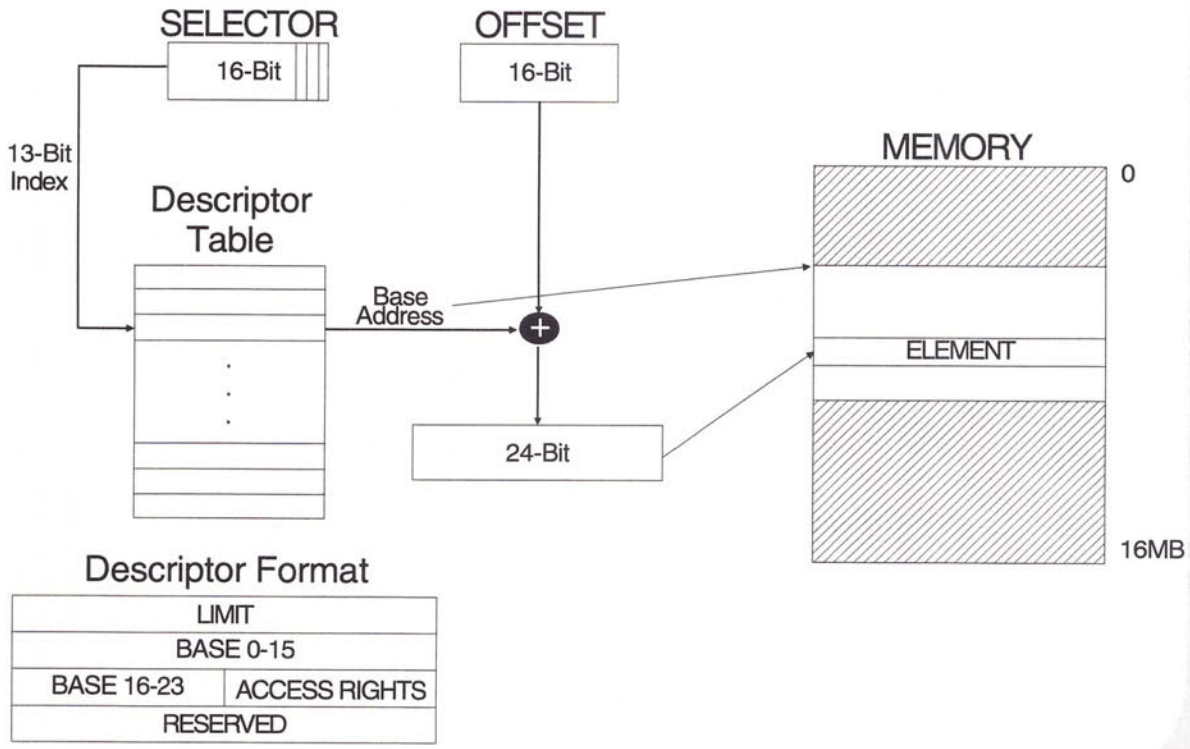


☐ Available in 80386/486. Reserved in the 80286

- ✓ 8 bytes that describe a Data Segment.
- ✓ Contains a full 32-bit address (24-bit in the 80286).
- ✓ Contains segment size (limit) and access rights.

20PMOD08 920709

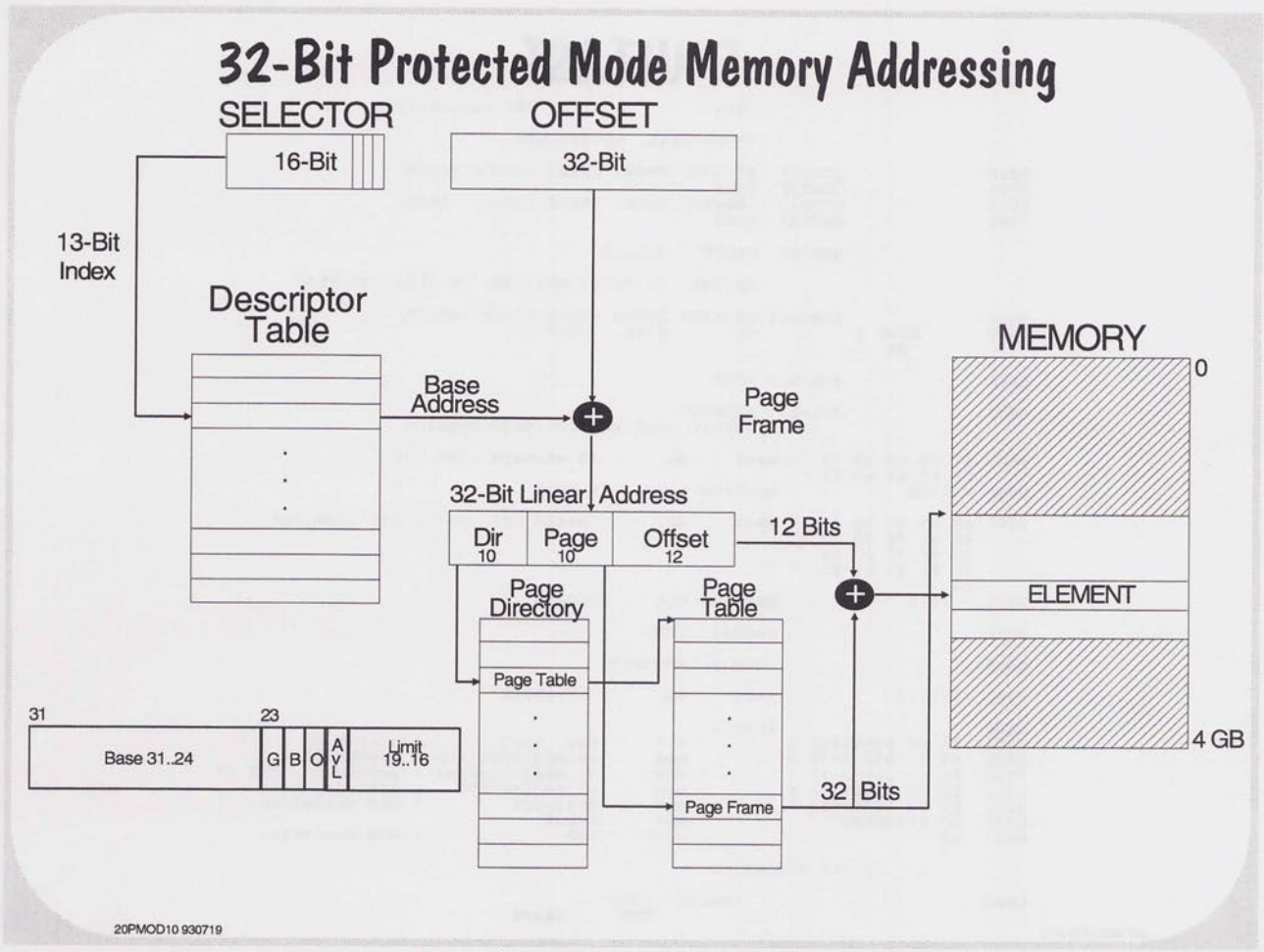
16-Bit Protected Mode Memory Addressing



Descriptor Format

LIMIT	
BASE 0-15	
BASE 16-23	ACCESS RIGHTS
RESERVED	

20PMOD09 920709

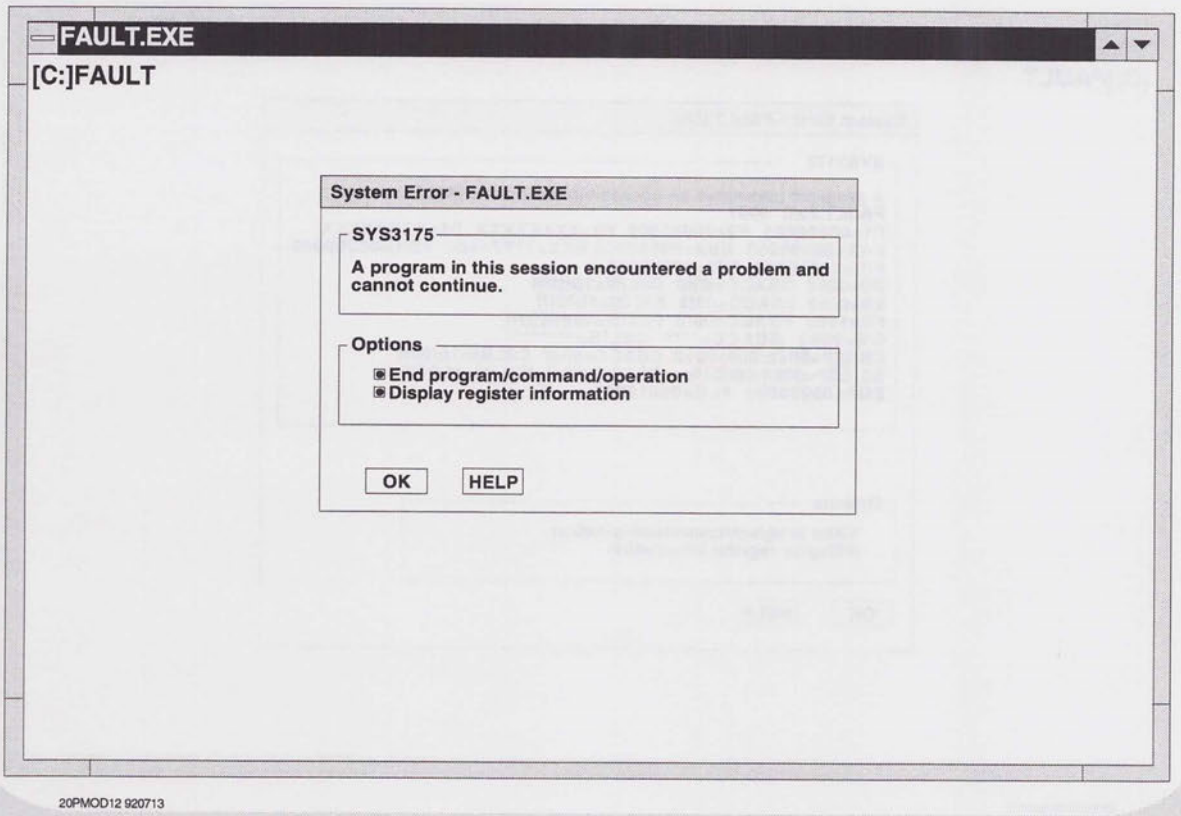

32-Bit Protected Mode Memory Addressing
SELECTOR
16-Bit
OFFSET
32-Bit
13-Bit
Index
Descriptor
Table
Base
Address
Page
Frame
MEMORY
0
4 GB
ELEMENT
32-Bit Linear Address
Dir
10
Page
10
Offset
12
12 Bits
Page
Directory
Page Table
Page
Table
Page Frame
32 Bits
31
23
Base 31..24
G
B
O
AVL
Limit
19..16
20PMOD10 930719

FAULT.LST

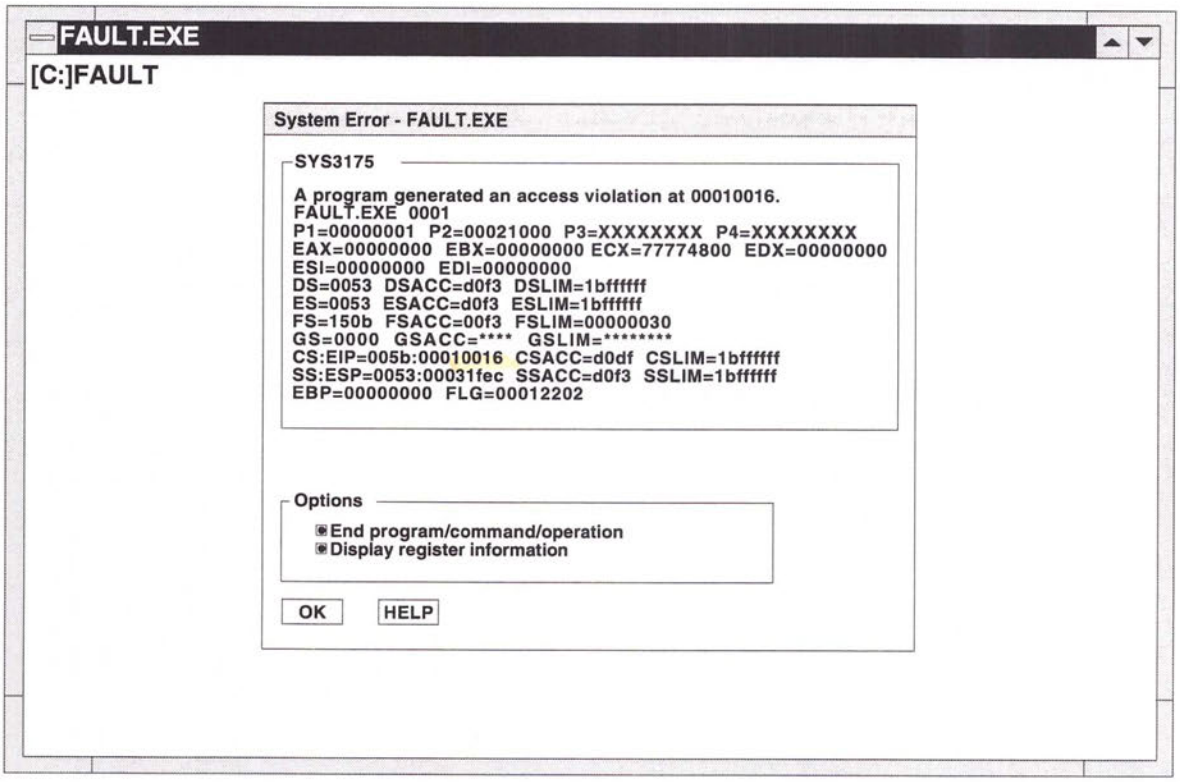
```
                                .386        ; allow 386 instructions

                                INCLUDELIB  OS2386.LIB

0000                    CODE32  SEGMENT DWORD USE32 PUBLIC 'CODE'
0000                    CODE32  ENDS
0000                    DATA32  SEGMENT DWORD USE32 PUBLIC 'DATA'
0000                    DATA32  ENDS

                        DGROUP  GROUP   data32

                                ASSUME  CS:FLAT, DS:FLAT, SS:FLAT, ES:FLAT

0000                    stack32 SEGMENT DWORD USE32 STACK 'STACK'
0000            2000 [  db      8192    DUP (?)
                 00
                ]
2000                    stack32 ENDS

0000                    data32  SEGMENT
                                PUBLIC msg1,msg1len,msg2,msg2len

0000 41 20 6D 65 73 73  msg1    db      'A message',0dh,0ah
     61 67 65 0D 0A
000B = 000B                     msg1len equ     $-msg1

000B 48 65 6C 6C 6F 20  msg2    db      'Hello OS/2 World !!!',0dh,0ah
     4F 53 2F 32 20
     57 6F 72 6C 64
     20 21 21 21 0D
     0A
0021 = 0016                     msg2len equ     $-msg2

0021                            data32  ENDS

0000                            code32  SEGMENT

0000 77777777                   var1    dd      77777777h

0004                            Start:
0004  8B 0D 00000000 R                 mov     ecx, var1       ; access OK
000A  8A 2D 0000000B R                 mov     ch,msg1+msg1len ; access OK
0010  8A 0D 00000021 R                 mov     cl,msg2+msg2len ; access OK. WHY ??
0016  8A 0D 00001000 R                 mov     cl,msg2+0ff5h   ; 1st violation
001C  89 0D 00000000 R                 mov     var1,ecx        ; 2nd violation
0022  BC 00000000                      mov     esp,0
0027  50                               push    eax             ; 3rd violation

                ; 4th violation

0028                             code32  ENDS
                                         END     Start
```

20PMOD18 920713

First Violation - Part 1

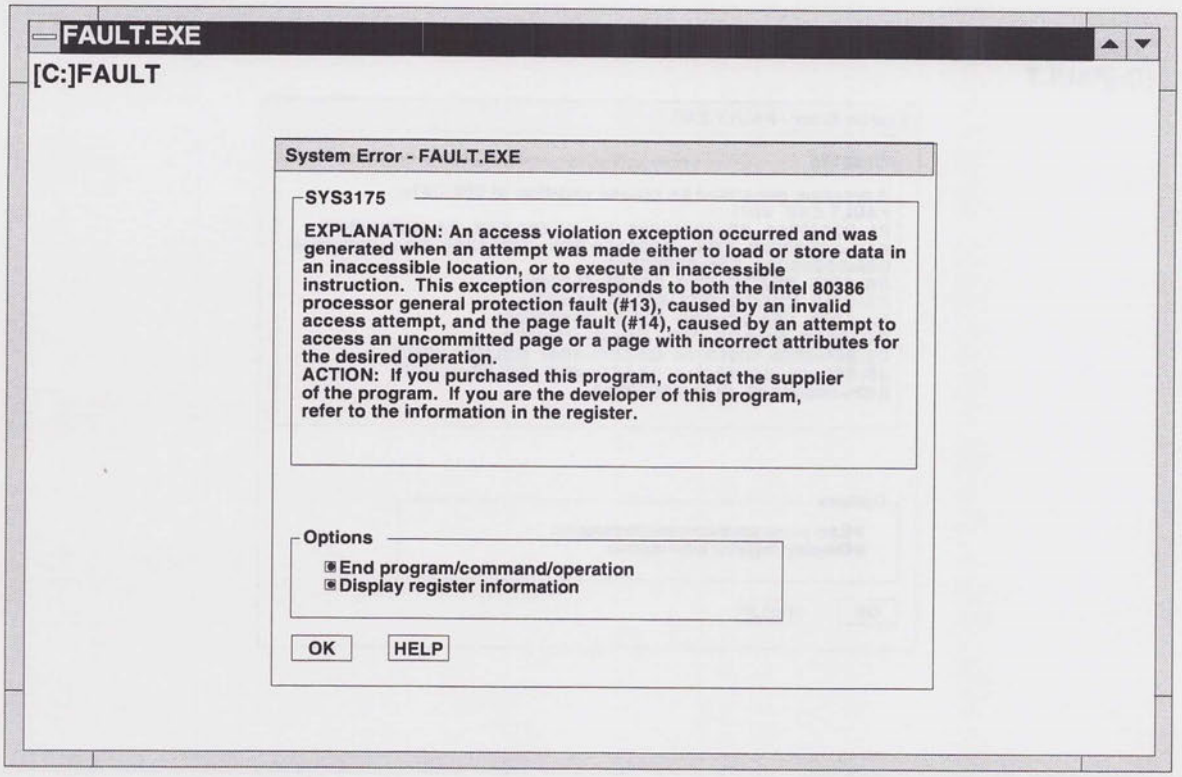


First Violation - Part 2



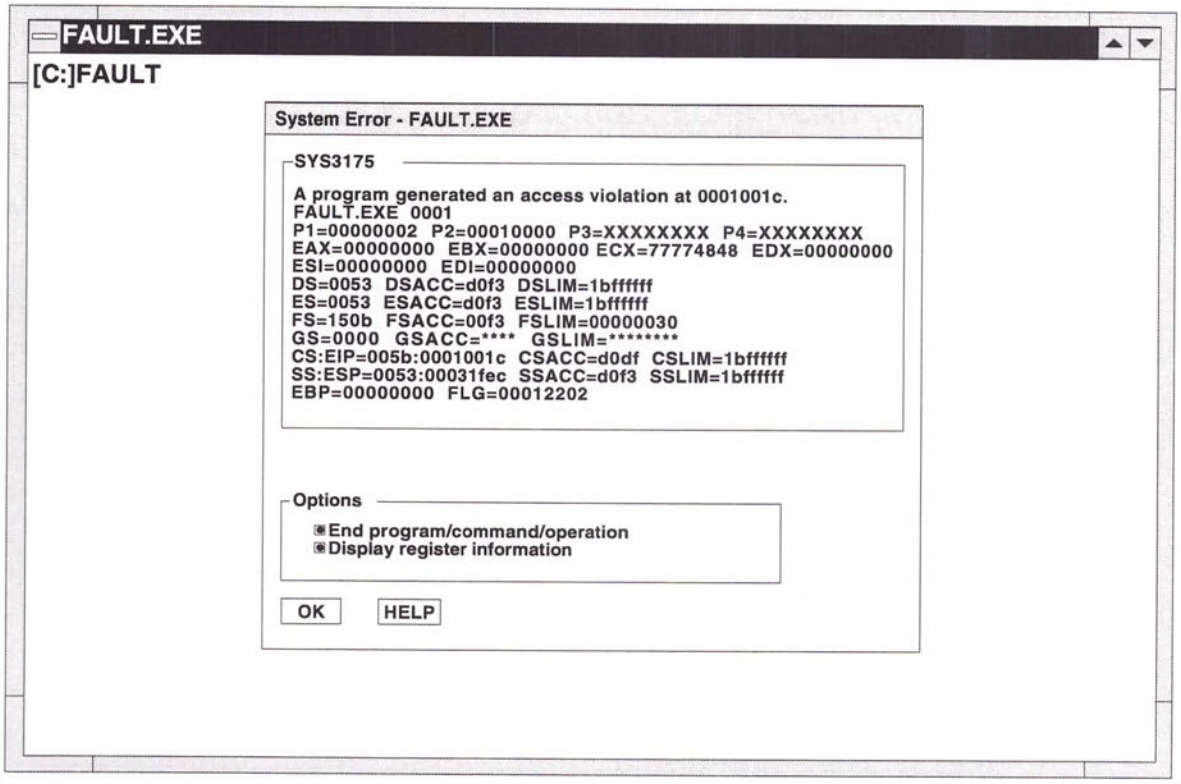
- highlighted is virtual address fault happened (10016)

First Violation - Part 3



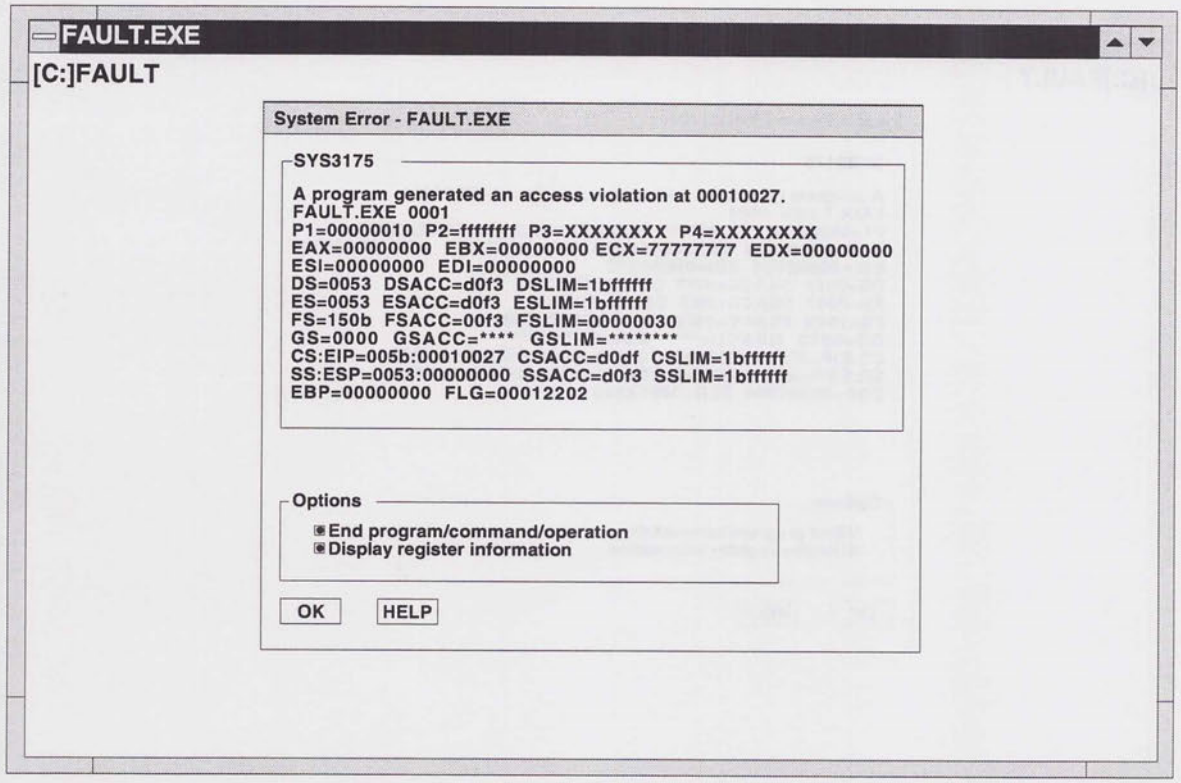
20PMOD14 920713

Second Violation



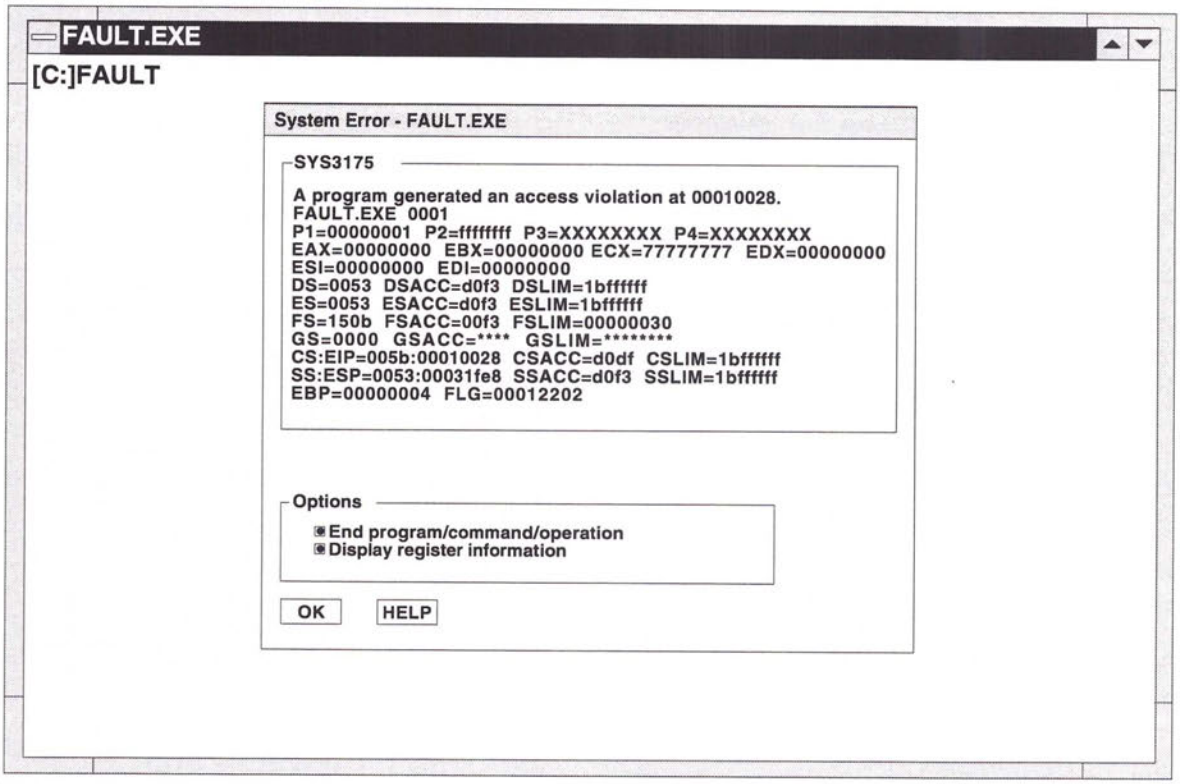
20PMOD15 920713

Third Violation



20PMOD16 920713

Fourth Violation



20PMOD17 920713

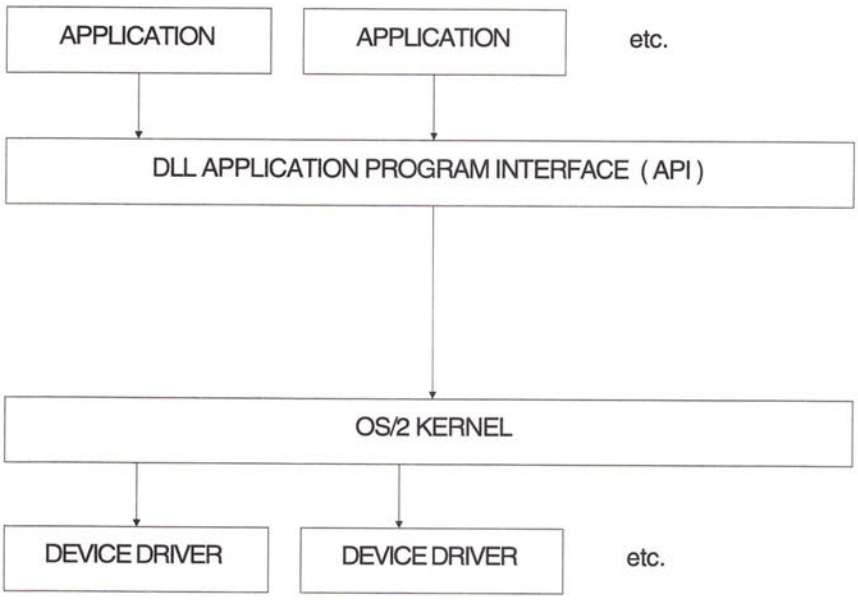
Introduction to OS/2 Programming

API interface
Return Codes

20PRGM01 920710

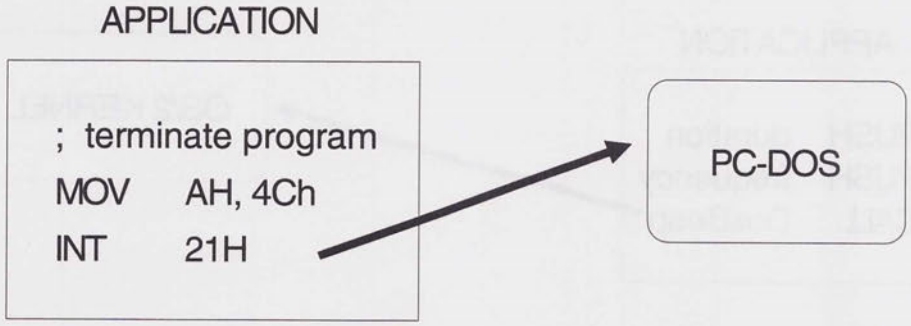
DISK 1 — COURSE MATERIALS
DISK 2 — INR FILES (EXTRAS)

OS/2 Application Interface



20PRGM02 920710

DOS Register-Based API



- ✓ Pass parameters via registers.
- ✓ Link to DOS through a software interrupt.
- ✓ Very efficient but, difficult to do from a high-level language.

20PRGM03 920710

OS/2 Call-Based API

- Passing paramters on the stack is compatible with most high level languages.

20PRGM04 930125

Using the C Language for OS/2

```
#define INCL_BASE
#define INCL_NOPMAPI
#include <os2.h>

int main ()
{


  return (NO_ERROR);
}
```

STANDARD LOCATION of .h files
SET UP IN CONFIG.SYS
VAR = INCLUDE

- OS2.H contains the API function prototypes.
- INCL_BASE limits the processing of function prototypes to base kernel functions.

20PRGM05 930910

API Function Prototypes

causes stack passing of parms

```
VOID APIENTRY DosExit ( ULONG action,    /* 0=end current thread, 1=end process */
                        ULONG result);   /* program completion code*/

APIRET APIENTRY DosBeep ( ULONG freq,    /* frequency of sound in hertz */
                          ULONG dur);    /* length of sound in milliseconds */
```

- ✓ ANSI 'C' Standard
- ✓ Extended 'C' compiler error checking
- ✓ Interface is independent of model of compilation used

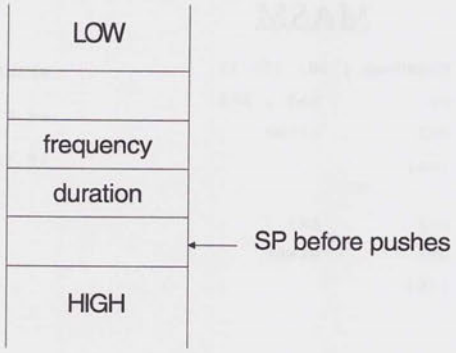
20PRGM06 921020

-HELP C compiler command line METHOD
> VIEW PROGREF21 DOSEXIT

_System Calling Convention

APIRET _System DosBeep (ULONG, ULONG);

```
DosBeep  ( frequency , duration );
```



- Parameters are pushed on the stack in right-to-left order as in normal C.
- The 'caller' clears parameters from the stack.
- The IBM C/C++ compiler's default method of passing parameters is to use a combination hardware registers and the stack. This is called Optlink.
- OS/2 ver. 1x uses the pascal calling convention .

20PRGM07 930910

Return Codes

MASM

```
@DosBeep ( 50, 300 );
OR          EAX , EAX
JNZ         error
(JZ)
       or
CMP         EAX,0
JNE         error
(JE)
```

C

```
APIRET rc;

rc = DosBeep (50, 300);

if (rc) printf ( "rc=%d Unable to beep speaker\n",rc);
```

- ✓ Always returned in the EAX register. 0 = NO_ERROR.
- ✓ Return codes are documented in the OS/2 2.0 Technical Library reference materials.

20PRGM08 930910

Class Exercise

Given the following 'C' function prototype, how many bytes of stack space are necessary for the parameters?

```
APIRET APIENTRY DosWrite (
        HFILE  hFile,           // File handle
        PVOID  pBuffer,         // Output buffer
        ULONG  cbWrite,         // Number of bytes to be written
        PULONG pcbActual);      // Number of bytes written (returned)
```

20PRGM09 920710

Notes

Environment Strings and Command Line Arguments

Accessing the Environment

Accessing the Command Line

20ENVR01 920710

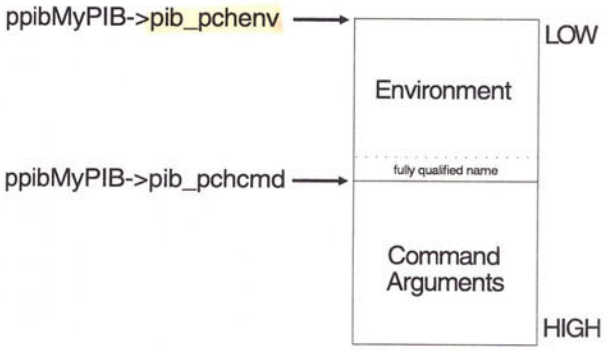
Obtaining Environment and Command Line Pointers

```
DosGetInfoBlocks ( PTIB  *ptib,    --> ptr to ThreadInfoBlock1
                   PPIB  *ppib );  --> ptr to ProcessInfoBlock
```

```
struct pib_s
  {
   ULONG  pib_ulpid;
   ULONG  pib_ulppid;
   ULONG   pib_hmte;
   PCHAR  pib_pchcmd;
   PCHAR  pib_pchenv;
   ULONG  pib_flstatus;
   ULONG  pib_ultype;
  };
```

```
struct tib2_s
  {
   ULONG  tib2_ultid;
   ULONG  tib2_ulpri;
   ULONG  tib2_version;
   USHORT  tib2_usMCCount;
   USHORT  tib2_fMCForceFlag;
  };
```

```
struct tib_s
  {
   PVOID  tib_pexchain;
   PVOID   tib_pstack;
   PVOID  tib_pstacklimit;
   PTIB2   tib_ptib2;
   ULONG tib_version;
   PVOID  tib_ordinal;
  };
```




```
PTIB  ptibMyTIB;
PPIB  ppibMyPIB;
DosGetInfoBlocks (
  &ptibMyTIB, &ppibMyPIB );
```

DON'T NEED

↑ pointer to a pointer

ESTABLISHES PTR TO ENVIRONMENT STRUCTURE

- See Vol 2 page Lab 1b-3 for structure of environment of PPIB

Searching the Environment

```
DosScanEnv (PSZ  pszName,      <-- ptr to Name string (IN)
            PSZ  *ppszValue );--> ptr to variable to receive ptr to Value (OUT)
```

```
  0 NO_ERROR
203 ERROR_ENVVAR_NOT_FOUND
```

- ✓ Searches the environment for a specified ASCII string (Name).
- ✓ The Name string must not include the equal (=) character.
- ✓ Returns a pointer to the value assigned to the environment variable.

```
PSZ  pszName = "PATH";
PSZ  pszValue;

DosScanEnv ( pszName, &pszValue );
printf ("Path = %s\n", pszValue);
```

20ENVR03 921008

Environment Strings

- Each process owns a set of environment strings.
- Each string has the form: <name>=<value> \0.
- The last string is terminated with \0\0.
- The fully expanded path of the executable file follows the last environment string.
- Example:

  icc /c /Ss /Ti /W3 /Gs browse.c

```
30000  43 4F 4D 53 50 45 43 3D 43 3A 5C 43 4D 44 2E 45  COMSPEC=C:\CMD.E
30010  58 45 00 50 41 54 48 3D 43 3A 5C 3B 43 3A 5C 49  XE.PATH=C:\;C:\I
30020  42 4D 43 32 5C 42 49 4E 3B 00 44 50 41 54 48 3D  BMC2\BIN;.DPATH=
30030  43 3A 5C 3B 43 3A 5C 49 42 4D 43 5C 42 49 4E 3B  C:\;C:\IBMC\BIN;
30040  20 00 00 43 3A 5C 49 42 4D 43 32 5C 42 49 4E 49   ..C:\IBMC\BIN\I
30050  43 43 2E 45 58 45 00                             CC.EXE.
```

20ENVR04 930910

Command Line

- Unlike the C compiler, OS/2 does not format the command line.
- The command (program name) is terminated with \0
- The the remainder of the command line is terminated with \0\0
- Example:

  C> icc /c /Ss /Ti /W3 /Gs browse.c

```
30057  69 63 63 00 20 2F 63 20 2F 53 73 20 2F 54 59 20  icc. /c /Ss /Ti
30067  2F 57 33 20 2F 47 73 20 42 52 4F 57 53 45 2E 43  /W3 /Gs browse.c
30077  00 00                                           ..
```

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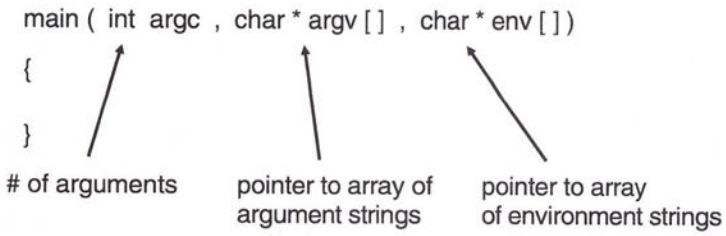
'C' Program Entry State



- ✓ 'C' startup code formats the arguments into null-terminated strings.
- ✓ EXAMPLE:

C>environ this is a test <cr>

argc = 5
argv[0] = "environ"
argv[1] = "this"
argv[2] = "is"
argv[3] = "a"
argv[4] = "test"

20ENVR06 920710

DosScanEnv Program Example

```
//  scanenv.c  --  displays the current path
//  ****** OS/2 Version 2.x ******

#define INCL_BASE
#include <os2.h>
#include <stdio.h>

#define     STDOUT  1

//  internal function prototypes

int terminate ( PSZ pszMsg, APIRET rc, PSZ pszMyName );

//  Globals

    int main (void)
{
    APIRET  rc;
    PSZ pszMyName = "SCANENV:";

    PSZ     pszName = "PATH";
    PSZ     pszValue;

    rc = DosScanEnv ( pszName, &pszValue );
    if (rc) terminate ("ScanEnv error !\n", rc, pszMyName);

    printf ("The current path is - %s\n", pszValue);

    return ( NO_ERROR );

}
/*****************************************************************/
int terminate ( PSZ pszMsg, APIRET rc, PSZ pszMyName)
{
    CHAR    chMsg[255];
    PSZ     pszMsgFile = "OSO001.MSG";
    ULONG   ulMsgLen;

    printf ("%s: Error #%d %s \n", pszMyName, rc, pszMsg);
    if (rc != 0 & rc != -1)
    {
      DosGetMessage (0, 0, (PCHAR) chMsg, 255L, rc, pszMsgFile, &ulMsgLen);
      DosPutMessage (STDOUT, ulMsgLen, chMsg );
    }
    exit (1);
}
```

20ENVR07 931109

Notes

Program Development

Programming Tools
Development Process

20DLVP01 920711

Programming Tools

- ✓ Include and Header files
- ✓ Sample Programs
- ✓ Presentation Manager Utilities
- ✓ Help Manager Utilities
- ✓ Message Utilities
- ✓ WorkFrame/2

20DLVP02 920711

Header and Include Files

- The INCLUDE statement automatically calls a hierarchy of header/include files.
- The DEFINE/EQU statements are used to control which group of functions are included.
- Header/include file hierarchy:

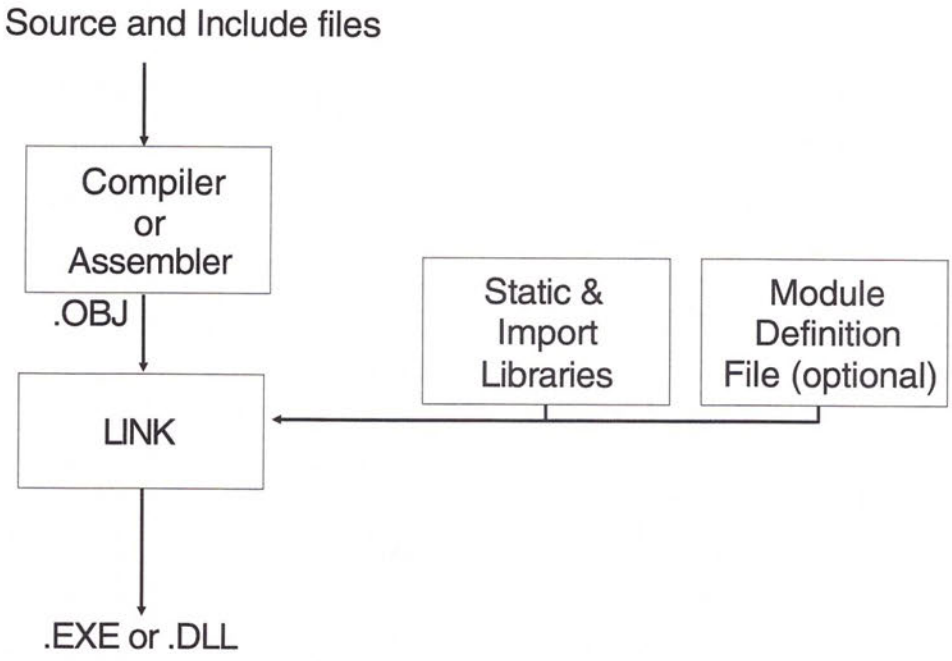
OS2.H (.INC)
- OS2DEF
- BSE
  - BSEDOS
  - BSESUB
  - BSEERR
  - BSEDEV
  - BSEMEMF
  - BSEORD
  - BSETIB
  - BSEXCPT

PM
- PMWIN
- PMGPI
- PMDEV
- PMAVIO
- PMSPL
- PMPIC
- PMORD
- PMBITMAP
- PMFONT
- PMDDI
- PMDDIM
- PMERR
- PMHELP
- PMMLE
- PMSEI
- PMSHL
- PMWP

20DLVP03 920711

TIB = Thread Information Block

OS/2 Development Process



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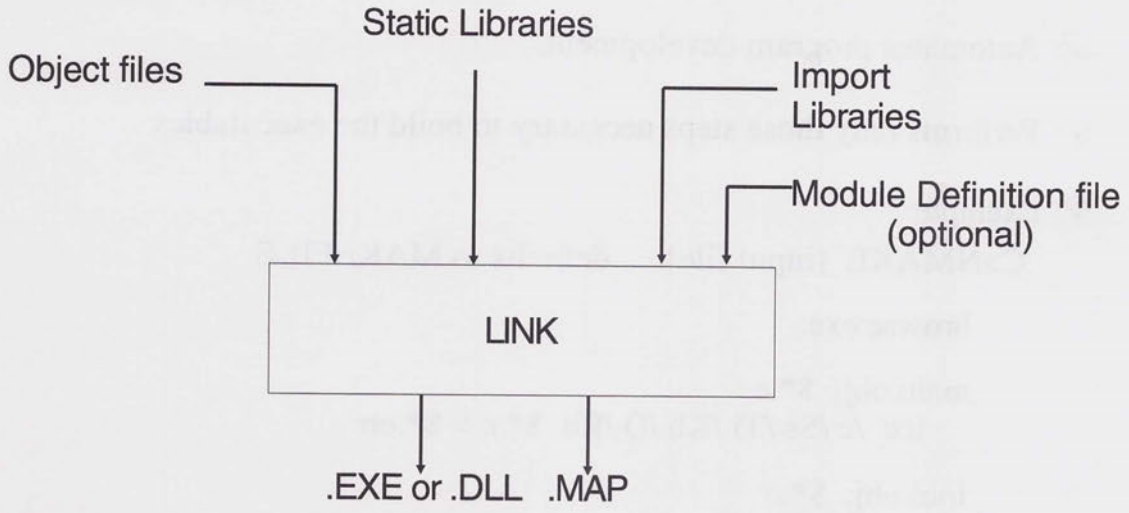
OS/2 Linker



20DLVP06 920711

NMAKE

Program Maintenance Utility

- Automates program development.
- Performs only those steps necessary to build the executables.
- Example:

  C>NMAKE [input file] defaults to MAKEFILE

```
browse.exe:

main.obj: $*.c
   icc /c /Ss /Ti /Kb /Q /Rn $*.c > $*.err

tool.obj: $*.c
   icc /c /Ss /Ti /Kb /Q /Rn $*.c > $*.err

screen.obj: $*.c
   icc /c /Ss /Ti /Kb /Q /Rn $*.c > $*.err

browse.exe: main.obj tool.obj screen.obj main.def
   LINK386 /DE /LI /BASE:0x10000 main tool screen, , , , main;
```

20DLVP05 930910

Memory Management

OS/2 Memory Model

Memory Objects

Allocation of Memory Objects

Suballocation of Memory Objects

20MAPI01 920726

- static Allocation - ex. program load
- dynamic Allocation - mem alloc when pgm needs. (DosAllocMem 4K min)
- Automatic allocation - variable declares (stack alloc.)

_ use Malloc for small memory allocation.

Actually uses 64k memory boundary, each ~~alloc DosMemAlloc~~
DosAllocMem gives 4k min, but uses 64k shared memory!

The Flat Memory Model

- OS/2 2.x defines a 32-bit memory model that is designed to be portable to any 32-bit uniprocessor or multiprocessor architecture including RISC.
- The model provides for memory objects that are larger than 64KB or larger than physical memory.
- The 80386/486 processors provide for a paged-virtual memory and 32-bit wide segments which may be up to 4GB in size.
- The 32-bit segment can be used to simulate a large, flat 32-bit virtual address space that is contiguous.
- On the 80386/486, a segmented virtual address (16:16 or 16:32) is translated by descriptors into a 32-bit (flat) linear address, which in turn is mapped to a 32-bit physical address by page tables.
- A pair of code and data descriptors maps the entire linear address space, effectively 'flattening' the virtual address space.

20MAPI02 930419

Virtual Address Space

- In the flat model, a linear address is a virtual address. A virtual address is also called a 0:32 address.
- The System Virtual Address Space is mapped by a pair of GDT code and data descriptors with limit fields of 4GB.
- The Process Virtual Address Space is mapped by a pair of GDT code and data descriptors with limit fields of 512MB. The 512MB limit provides compatibility with 16-bit applications and may be removed in the future.
- The process is provided with an independent 512MB linear address space by its own set of page directories and page tables.
- The virtual address space is partitioned in to private and shared regions.
- Private memory is allocated from low addresses toward higher addresses and shared memory is allocated from high addresses toward lower addresses.

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Memory Objects

- The smallest memory unit in the flat model is a page (4KB).
- A memory object is a range of contiguous linear pages within the process virtual address space.
- All memory objects are addressable simultaneously.
- Memory objects are nonrelocatable and, the pages that compose the objects are swappable.

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Types of Memory Objects

Application Code	Private Address, Shared Storage
Application R/O Data	Private Address, Shared Storage
Application R/W Data	Private Address, Private Storage
Application Allocated Private Memory	Private Address, Private Storage
Dynamic Link Allocated Private Memory	Private Address, Private Storage
Application Allocated Shared Memory	Shared Address, Shared Storage
Dynamic Link Allocated Shared Memory	Shared Address, Shared Storage
Dynamic Link Instance Data	Shared Address, Private Storage
Dynamic Link Static Data	Shared Address, Shared Storage
Dynamic Link Code	Shared Address, Shared Storage

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DosAllocMem

```
DosAllocMem (PPVOID  ppb,      --> pointer to pointer
             ULONG   cb,       <-- size in bytes
             ULONG   flag );   <-- allocation flags
```

0	NO_ERROR
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT

PAG_READ	0x00000001
PAG_WRITE	0x00000002
PAG_EXECUTE	0x00000004
PAG_COMMIT	0x00000010
OBJ_TILE	0x00000040
fPERM	(PAG_EXECUTE+PAG_READ+PAG_WRITE)
fALLOC	(OBJ_TILE+PAG_COMMIT+fPERM)

```
PVOID  pArray6;

ulAllocFlags=PAG_READ | PAG_WRITE | PAG_COMMIT;
DosAllocMem (  &pArray6, 0x200, ulAllocFlags );
```

20MAPI06 921020

- creates memory object who's minimum size is 4k and uses a minimum of 64k shared (virtual) space.

bse(mf).h contains declare/prototype

DosFreeMem

DosFreeMem (PVOID pb); <-- base address of memory object

0	NO_ERROR
5	ERROR_ACCESS_DENIED
95	ERROR_INTERRUPT
487	ERROR_INVALID_ADDRESS

- Deallocates a private memory object.
- For a shared memory object, the reference count is decremented. If the resulting count is zero (0), the object is deallocated.

```
DosFreeMem ( pb );
```

20MAPI7 921020

– dont bother if your process is exiting. OS/2 will do it for you.

DosQueryMem

```
DosQueryMem ( PVOID  pb,        <-- starting address
              PULONG pcb,       <--> size of region
              PULONG pFlag );   -->flags found
```

0	NO_ERROR
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT
487	ERROR_INVALID_ADDRESS

PAG_READ	0x00000001
PAG_WRITE	0x00000002
PAG_EXECUTE	0x00000004
PAG_GUARD	0x00000008
PAG_COMMIT	0x00000010
PAG_SHARED	0x00002000
PAG_FREE	0x00004000
PAG_BASE	0x00010000

- Returns attribute information about a range of pages within the process virtual address space.
- The query terminates at the end of the region or when a non-matching attribute is detected or when the base page of an object is encountered.

```
DosQueryMem ( pb, &cb, &Flag );

     Base 0x00480000  Length 0x00001000  Flags 0x00010017
     Base 0x00481000  Length 0x0000F000  Flags 0x00000007
     Base 0x00490000  Length 0x00001000  Flags 0x00010017
     Base 0x00491000  Length 0x0000F000  Flags 0x00000007
     Base 0x004A0000  Length 0x00001000  Flags 0x00010013
     Base 0x004A1000  Length 0x0000F000  Flags 0x00000003
```

20MAPI08 921020

almost never used

DosSetMem

```
DosSetMem ( PVOID  pb,      <-- region address
            ULONG  cb,      <-- number of bytes
            ULONG  flag );  <-- access requested
```

0	NO_ERROR
5	ERROR_ACCESS_DENIED
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT
212	ERROR_LOCKED
487	ERROR_INVALID_ADDRESS
32798	ERROR_CROSSES_OBJECT_BOUNDARY

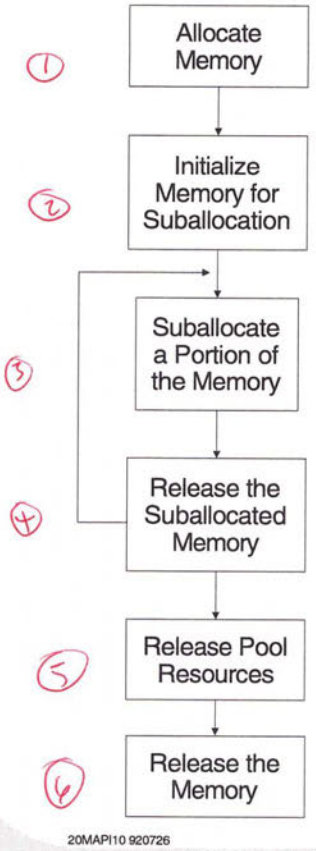
PAG_READ	0x00000001
PAG_WRITE	0x00000002
PAG_EXECUTE	0x00000004
PAG_GUARD	0x00000008
PAG_COMMIT	0x00000010
PAG_DECOMMIT	0x00000020
PAG_DEFAULT	0x00000400
fPERM (PAG_EXECUTE+PAG_READ+PAG_WRITE)	
fSET (PAG_COMMIT+PAG_DECOMMIT+PAG_DEFAULT+fPERM)	

- Sets the attributes of a range of pages within a memory object.

```
DosSetMem ( pb, 4096, PAG_COMMIT | PAG_DEFAULT );
```

20MAPI 09 921020

Suballocation of Memory



DosAllocMem (Ptr, Size, AllocFlags)

DosSubSetMem (PoolPtr, Flags, Size)

DosSubAllocMem (PoolPtr, BlockPtr, Size)

DosSubFreeMem (PoolPtr, BlockPtr, Size)

DosSubUnsetMem (PoolPtr)

DosFreeMem (Ptr)

OS/2 only

Will work between processes, ie shared memory.

DosSubSetMem

```
DosSubSetMem ( PVOID  pb,      <-- address of memory pool
               ULONG  flag,    <-- suballocated object characteristics
               ULONG cb );     <-- size in bytes of the pool
```

0	NO_ERROR
87	ERROR_INVALID_PARAMETER
310	ERROR_DOSSUB_SHRINK

DOSSUB_INIT	0x01
DOSSUB_GROW	0x02
DOSSUB_SPARSE_OBJ	0x04
DOSSUB_SERIALIZE	0x08

- Initializes, increases in size or enables access by another process to the memory pool. The first process does DOSSUB_INIT.
- The first 64 bytes are used by the pool manager.
- If suballocating between threads in the same process or another process, DOSSUB_SERIALIZE will ensure that accesses are serialized.
- If the 'parent' object was allocated sparse, DOSSUB_SPARSE_OBJ is necessary to have memory committed as necessary.

```
DosSubSetMem ( pb, DOSSUB_INIT | DOSSUB_SPARSE_OBJ, 16384 );
```

20MAPI11 940125

DosSubAllocMem, DosSubFreeMem

```
DosSubAllocMem ( PVOID  pbBase,    <-- address of memory pool
                 PPVOID ppb,       --> address of block allocated
                 ULONG  cb );      <-- size requested in bytes
```

0	NO_ERROR
87	ERROR_INVALID_PARAMETER
311	ERROR_DOSSUB_NOMEM
532	ERROR_DOSSUB_CORRUPTED

```
PVOID  pb;
DosSubAllocMem ( pbBase, &pb, 256 );
```

```
DosSubFreeMem ( PVOID  pbBase,    <-- address of memory pool
                PVOID  pb,        <-- address of block to be freed
                ULONG  cb );      <-- size in bytes
```

0	NO_ERROR
87	ERROR_INVALID_PARAMETER
312	ERROR_DOSSUB_OVERLAP
532	ERROR_DOSSUB_CORRUPTED

```
DosSubFreeMem ( pbBase, pb, 56 );
```

20MAPI12 921020

DosSubUnsetMem

DosSubUnsetMem (PVOID pbBase); <-- address of memory pool

0	NO_ERROR
532	ERROR_DOSSUB_CORRUPTED

- ✓ Ends the use of a memory pool.
- ✓ Releases the resources used to manage the suballocation of the pool.
- ✓ Each thread that calls DosSubSetMem must call DosSubUnsetMem prior to the memory object being freed.

```
DosSubUnsetMem ( pbBase );
```

20MAPI13 921020

- do this before freeing memory.

Notes

Introduction to Multitasking

Serial Multitasking

Parallel Multitasking

OS/2 Elements of Multitasking

20MULT01 921026

Multiple Tasks

- Serial Tasks
  - Read a manual
  - Answer the phone
  - Write a memo
  - Create a spreadsheet
  - Read electronic mail
  - Schedule a meeting

- Parallel Tasks
  - Drive a car and talk on the phone
  - Jog and listen to the radio
  - Print a chart, download a data file and format a disk

20MULT02 921026

Parallel Multitasking

- ✓ True parallel multitasking requires multiple processors (CPUs).
- ✓ Currently, multiprocessor personal computers are rare.
- ✓ OS/2 is not considered a serial multitasking system.
- ✓ Preemptive scheduling of tasks gives the effect of parallelism.

20MULT03 921026

OS/2 Elements of Multitasking

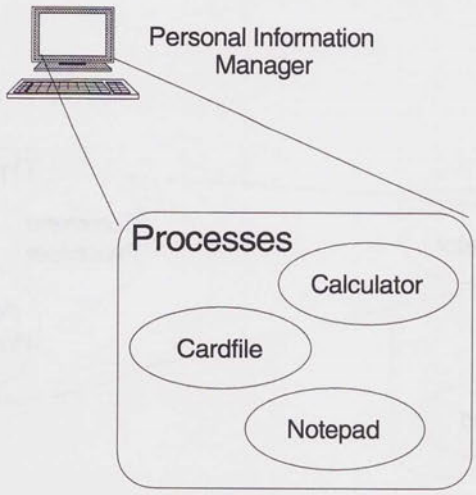
SESSIONS

- Each session is a virtual console device with its own keyboard video and mouse buffers.
- Switching between sessions usually means switching between applications.

20MULT04 921026

OS/2 Elements of Multitasking

PROCESSES



- A process is the unit of ownership in OS/2.
- Memory, open files and semaphores are system resources that are owned by a process.

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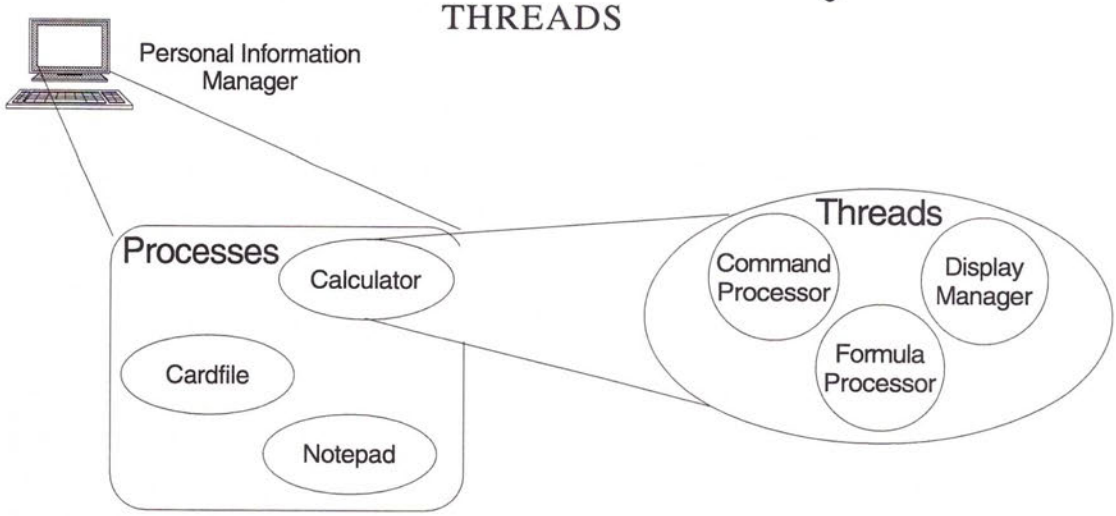
OS/2 Elements of Multitasking

THREADS



- A thread is a unit of work that is dispatched by the scheduler.
- Threads share the system resources owned by the process.

20MULT06 921026

Thread Management

Thread Hierarchy

Creating Threads

Thread States

Thread Priority

Configuration Parameters

Global, Static and Local 'C' Variables

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- All exception handlings are done in Thread #1

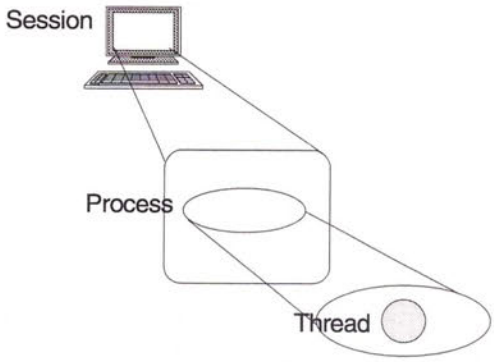
3 types:

① CTL-C

② CTL-BRK

③ KILL PROCESS

Thread Hierarchy



- A thread is a dispatchable unit of work.
- Each process has at least one thread.
- A thread owns:
  - stack segment
  - registers
  - priority
  - CPUstate
- Threads in the same process share page directories and tables.
- Threads in the same process are not protected from one another.

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- Main procedure is thread #1
- Use semaphores between threads to terminate
  not DosKillThread (no cleanup)

An Example of Three Threads

```
main ()
{
        createthread ( threadA );
        createthread ( threadB );
        suspendthread (main);
}

threadA ()
{
        while ( 1 )                    // do forever
        {
            putchar  ( "A" );
        }
}

threadB ()
{
        while ( 1 )                    // do forever
        {
            putchar  ( "B" );
        }
}
```

- ✓ 'main' does not call threadA or threadB directly.
- ✓ Although there are three threads, there is only one process.

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Another Example of Three Threads

```
main ()
{
        createthread ( threadA , 'A' );
        createthread ( threadA , 'B' );
        suspendthread (main);

}

threadA (char c)
{

        while ( 1 )                    // do forever
          {
              putchar ( c );
          }
}
```

- ✓ This example shows how 2 threads can execute the same code concurrently.
- ✓ Think of 'A' and 'B' as command line parameters.
- ✓ Each thread uses the same code, but different data.

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Thread States

- Once created, a thread is in one of these states:
  - Executing
  - Ready
  - Blocked
- Newly created threads may be put in the ready state or blocked state depending on the creation parameters.
- Only one thread is running at a time.
- The scheduler decides which thread will run based on the priorities of all threads ready to execute and current system load.

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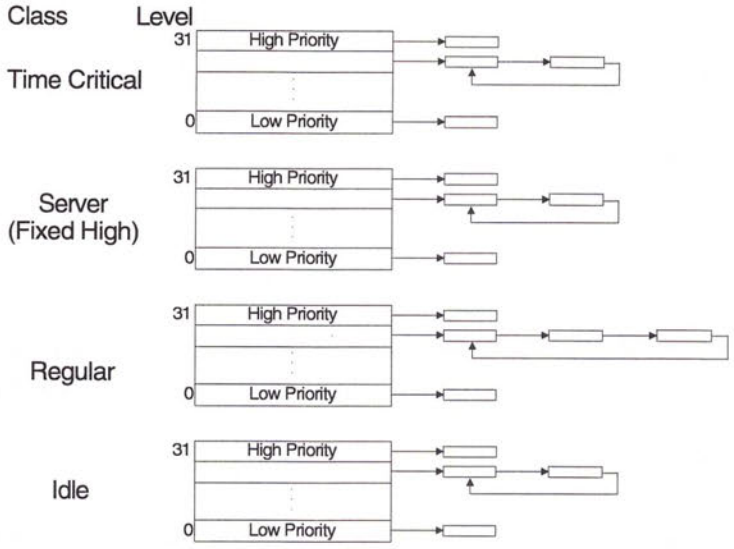
Priority Classes and Levels



- The initial priority of a thread is inherited from the creating thread.
- Each thread in the system is assigned a priority class and a priority level.
- OS/2 schedules threads at the same priority in round-robin order.

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→ For idle class processes, before terminating, set priority to Regular class to get enough cpu cycles to actually exit process.

Dynamic Priority Adjustment

- Dynamic priority adjustment is the scheduler's ability to alter the priority of threads in the regular class.
- All threads of the foreground process receive a priority boost. The thread performing the user I/O receives an additional boost.
- When a thread becomes ready to run as the result of an I/O operation completing, the priority is boosted to the highest level in the class.
- A thread that is ready to run but, has not executed for the MAXWAIT period, is boosted out of its current class to a level just below time critical.
- When a thread receives an I/O or starvation boost, its new priority and timeslice are retained until the thread executes for a single timeslice.

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Configuration Parameters Affecting Multitasking

(IN CONFIG.SYS)

- THREADS = 64 - 4095
  Controls the number of threads that may be created
- TIMESLICE = >=32 [,<65536]
  Specifies the CPU time allocated to each thread
- PRIORITY = [ABSOLUTE | DYNAMIC]
  Selects the priority calculation in scheduling Regular class threads.
- MAXWAIT = 1 - 255
  Specifies the max time a thread must wait for the CPU before having its priority boosted.
- PRIORITY_DISK_IO = Yes|No
  Foreground threads receive disk I/O priority.

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- DISABLES AUTOMATIC PRIORITY ADJUSTMENTS

Thread Management Functions

DosCreateThread
DosExit
DosKillThread
} Thread creation/termination

DosSuspendThread
DosResumeThread
DosEnterCritSec
DosExitCritSec
} Thread suspension/resumption

DosGetInfoBlocks

DosWaitThread

DosSetPriority

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DosGetInfoBlocks

```
DosGetInfoBlocks ( PTIB  *ptib,     --> ptr to ThreadInfoBlock1
                   PPIB  *ppib );   --> ptr to ProcessInfoBlock
```

```
struct pib_s
  {
   ULONG  pib_ulpid;
   ULONG  pib_ulppid;
   ULONG   pib_hmte;
   PCHAR   pib_pchcmd;
   PCHAR   pib_pchenv;
   ULONG  pib_flstatus;
   ULONG  pib_ultype;
  };
```

```
struct tib_s
  {
   PVOID  tib_pexchain;
   PVOID   tib_pstack;
   PVOID  tib_pstacklimit;
   PTIB2    tib_ptib2;
   ULONG tib_version;
   PVOID  tib_ordinal;
  };
```

```
struct tib2_s
  {
   ULONG  tib2_ultid;
   ULONG  tib2_ulpri;
   ULONG  tib2_version;
   USHORT  tib2_usMCCount;
   USHORT  tib2_fMCForceFlag;
  };
```

```
PTIB    ptib;
PPIB    ppib;
TID     tid;

DosGetInfoBlocks ( &ptib, &ppib )
tid = ptib->tib_ptib2->tib2_ultid;
```

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→ Retrieves thread id.

DosCreateThread

```
DosCreateThread ( PTID  ptid,          --> tid of created thread
                  PFNTHREAD  pfn,<-- function name
                  ULONG  param,    <-- argument value or reference
                  ULONG  flag,     <-- execution flag
                  ULONG  cbstack ); <-- stack maximum size
```

0	NO_ERROR
8	ERROR_NOT_ENOUGH_MEMORY
95	ERROR_INTERRUPT
115	ERROR_PROTECTION_VIOLATION
164	ERROR_MAX_THREADS_REACHED

0x0	CREATE_READY
0x1	CREATE_SUSPENDED
0x0	STACK_SPARSE
0x2	STACK_COMMITTED

- ✓ Asynchronous
- ✓ The specified stack size should include an additional page for the guard page.
- ✓ Initially, only the first two stack pages are committed with the second page a guard page unless bit 1 is set in the execution flag.
- ✓ The function being invoked must be defined with the IBM C Set/2 'system' linkage.

```
void _System readfile ( PVOID pRead );

DosCreateThread (&tid,(PFNTHREAD) readfile, (ULONG) pRead,
                 CREATE_READY | STACK_SPARSE, 8192 );
```

20THRD11 940125

- _System tells thread to expect parms passed on the Stack.

DosEnterCritSec, DosExitCritSec

DosEnterCritSec (VOID); no other thread can run

0	NO_ERROR
484	ERROR_CRITSEC_OVERFLOW

DosExitCritSec (VOID); other threads may run

0	NO_ERROR
484	ERROR_CRITSEC_OVERFLOW
485	ERROR_CRITSEC_UNDERFLOW

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DosSuspendThread, DosResumeThread

```
DosSuspendThread ( TID  tid );   <-- threadid
DosResumeThread ( TID  tid );    <-- threadid
```

0	NO_ERROR
309	ERROR_INVALID_THREADID

- Threads suspended by DosSuspendThread must be specifically restarted with DosResumeThread.
- If multiple suspends are issued to the same thread, an equal number of resumes must be executed before the thread can be dispatched.

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DosKillThread

DosKillThread (TID tid); <-- id of thread to terminate

0	NO_ERROR
170	ERROR_BUSY
309	ERROR_INVALID_THREADID

- ✓ May be used without restriction if the application was compiled with the subsystem library (/Rn).

- ✓ It will work with some restrictions with the multitasking libraries (/Gm) but, IS NOT RECOMMENDED.

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DosWaitThread

```
DosWaitThread (PTID  ptid,          <--> ptr to tid
               ULONG option );      <-- wait options
```

0	NO_ERROR
85	ERROR_INTERRUPT
294	ERROR_THREAD_NOT_TERMINATED
309	ERROR_INVALID_THREADID

0	DCWW_WAIT
1	DCWW_NOWAIT

- DosWaitThread will block until a SPECIFIC thread or ANY thread in the current process terminates.
- If TID=0, wait for any thread to terminate and return that thread's ID, otherwise, wait for specific thread.

```
APIRET rc = 0;
TID  tid;

While ( !rc )
{
  tid = 0;
  rc = DosWaitThread ( &tid, DCWW_WAIT );
}
```

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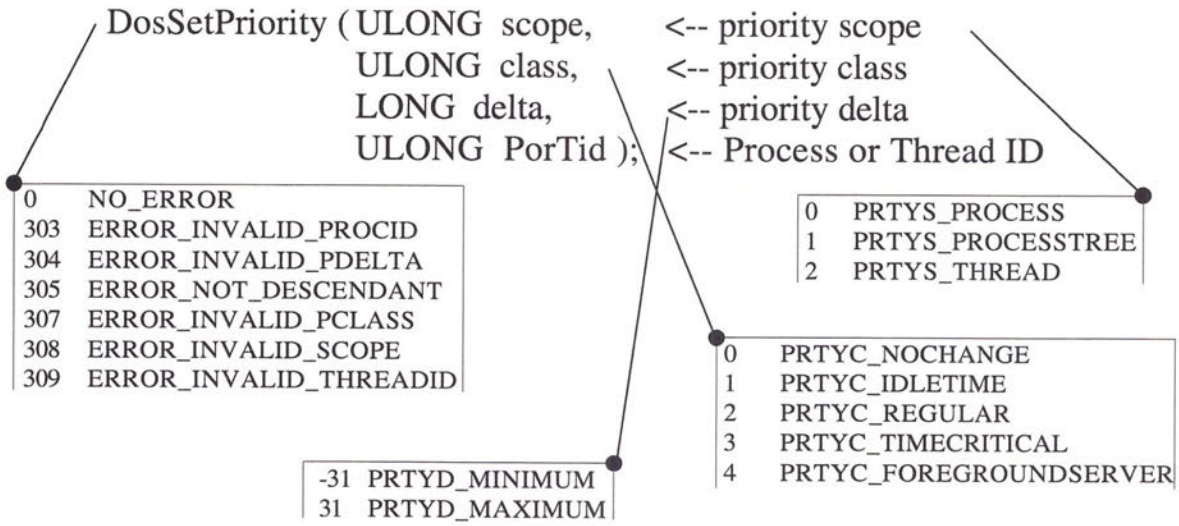
- During a Long Call an 85 (ERROR interrupt) will always be issued.

- IF NOWAIT is used & the thread you want to wait for is already running, you get a '294'

DosSetPriority




```
DosSetPriority ( PRTYS_THREAD, PRTYC_NOCHANGE, +5, tid );
```

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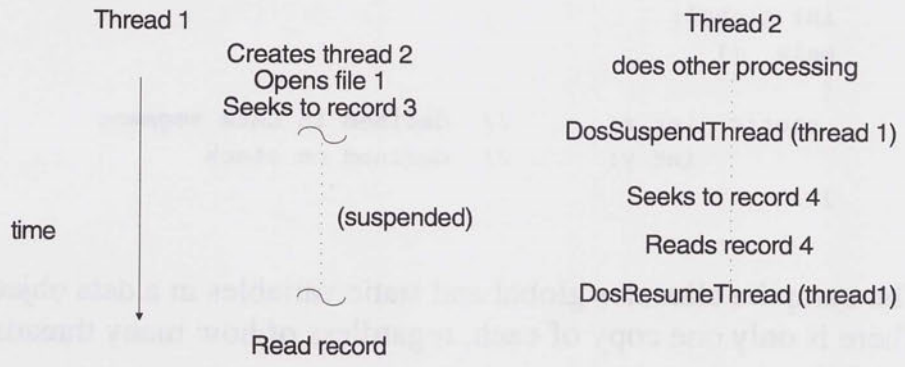
Mutual Exclusion Problems



- Which record does thread 1 read?

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Variables in C Programs

```
int global;
main  ()
{
 static  int x;       //  defined in data segment
         int y;       //  defined on stack
}
```

- The compiler allocates global and static variables in a data object. There is only one copy of each, regardless of how many threads are defined.

- Variables defined within braces are local variables. The compiler defines these on the stack.

- Each thread has its own stack. Therefore, each thread will have a separate copy of the local variables.

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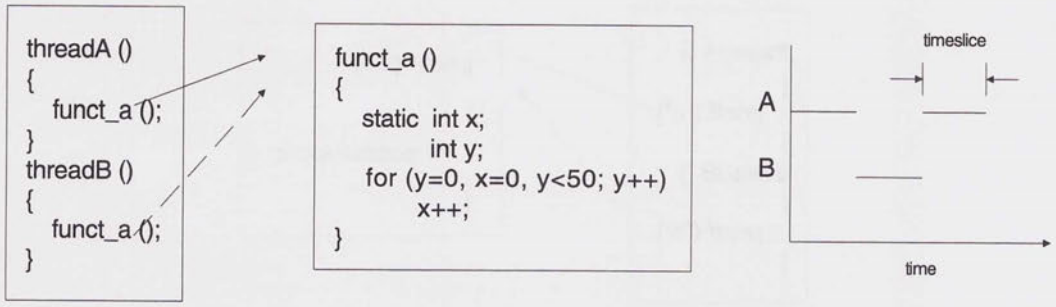
Reentrancy with Multiple Threads



- ThreadA calls funct_a and then is preempted by threadB. Assume x=y=25.
- ThreadB calls funct_a. A separate copy of 'y' is allocated but, the single copy of 'x' is initially cleared. ThreadA preempts ThreadB. Assume x=y=30.
- ThreadA uses 'x' which is now 30, NOT 25. Funct_a fails!
- Serializing access to the static variable through the use of a semaphore solves the problem.

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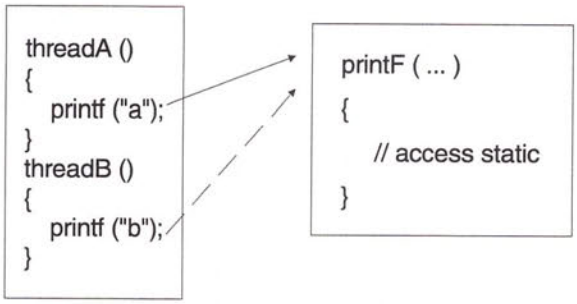
/Gm option on C compiler for re-entrant

Reentrancy with C Library Functions



- Several functions in the standard C library are not reentrant.
- Access to these functions must be serialized.
- The application must perform the serialization if multiple threads are created using the DosCreateThread function.
- Serialization will be provided by the C run-time library if threads are created using the '_beginthread' library function.

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_beginthread/_endthread C Library Functions

```
int  _beginthread (void (* _Optlink __thread) (void *),<-- function address
                   (void *),                            <-- ignored by C Set/2
                   unsigned,                            <-- stack size in bytes
                   void *);                             <-- ptr. to argument(s)

_endthread (void)
```

- ✓ _beginthread calls DosCreateThread and then performs thread specific initialization in the context of the new thread.
- ✓ Returns tid if successful or -1 on error.
- ✓ The function invoked must use the default Optlink linkage.
- ✓ Available in the multithread library (/Gm).
- ✓ Function prototypes are contained in process.h.

```
tid = _beginthread ( readfile, NULL, 8192, (PVOID) &Arg );
if ( tid == (TID) -1 ) terminate;
```

20THRD21 930628

use this for RE-ENTRANT code

_beginthread is used most often !!!!

DosCreateThread vs _beginthread

- DosCreateThread + Subsystem Lib (/Rn) = 
- DosCreateThread + Multi-Thread Lib (/Gm) = 
- _beginthread + Multi-Thread Lib (/Gm) = 

↓

DosCreateThread → Thread Specific Initialization

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Synchronization Using Semaphores

Major Uses of Semaphores

Classes and Types of Semaphores

Signaling Events

Serializing the Access to Resources

Monitoring Multiple Semaphores

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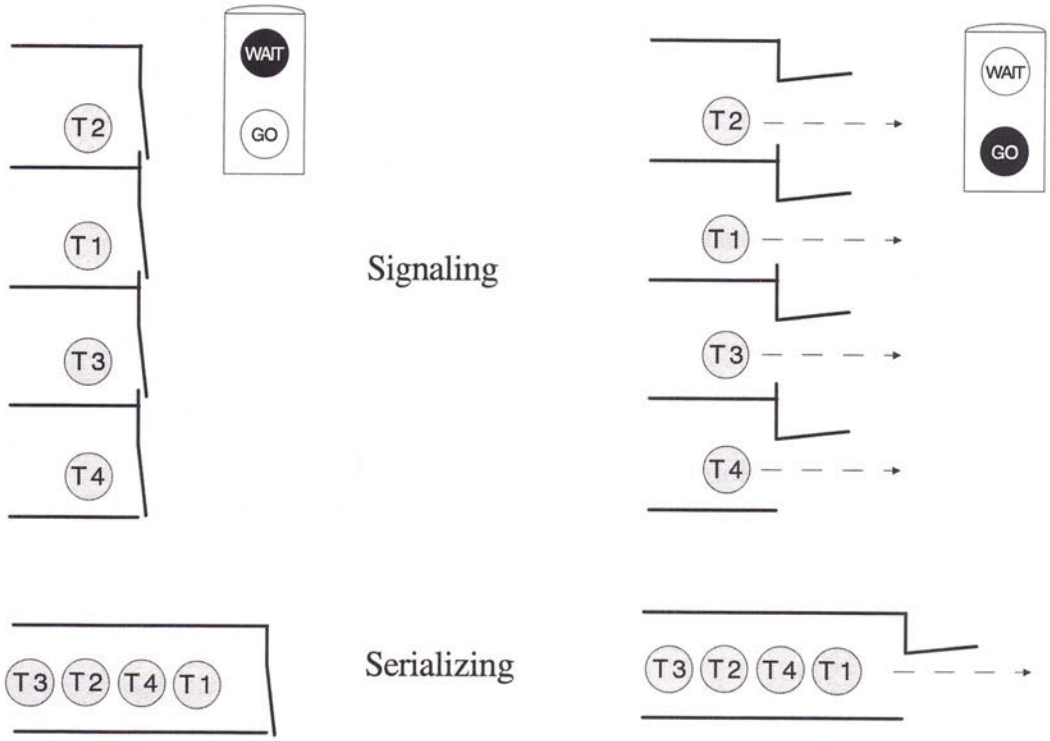
Uses of Semaphores



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— 64,000 shared Semaphores possible

Classes and Type of Semaphores

- Classes:

  Private - accessable by threads in the current process

  Shared - accessable by threads in any process

- Types:

  Event - used for signaling

  Mutex - used for serializing

  MuxWait - used for monitoring multiple Event or Mutex semaphores

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Application of OS/2 Semaphores

Use	Scope	Semaphore Type
Serialization	Between threads in different processes	Named Mutex Unnamed shared Mutex
Signaling	Between threads in different processes	Named Event Unnamed shared Event
Serialization	Between threads in one process	Unnamed Mutex
Signaling		Unnamed Event

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DosCreateEventSem

```
DosCreateEventSem ( PSZ  pszName,     <-- sem name or zero
                    PHEV  phev,        --> sem handle
                    ULONG  flAttr,     <-- DC Flags
                    BOOL32  fState );  <-- initial state
```

0	NO_ERROR
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
123	ERROR_INVALID_NAME
285	ERROR_DUPLICATE_NAME
290	ERROR_TOO_MANY_HANDLES

0x00	FALSE
0x01	TRUE

0x01	DC_SEM_SHARED

- Named event semaphores (\SEM32\) may be shared between processes by default. Unnamed semaphores may be designated as shared.
- If the state of the semaphore is false (reset), DosWaitEventSem will block.
- If the state of the semaphore is true (posted), the wait function will not block.

```
#define POSTED  TRUE
#define RESET   FALSE

DosCreateEventSem ( "\\SEM32\\MySem", &hev, 0, RESET );
```

20SEMA05 930206

DosOpenEventSem

```
DosOpenEventSem (PSZ  pszName,   <-- sem name or zero
                 PHEV  phev );   <--> sem handle
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
123	ERROR_INVALID_NAME
187	ERROR_ERROR_SEM_NOT_FOUND
291	ERROR_TOO_MANY_OPENS

- Makes available for use by ~~the calling~~ ANOTHER process an event semaphore that was previously created with the 'share' attribute.
- If opening a named event semaphore, the sem handle must be initialized to zero prior to the open.
- If opening an unnamed event semaphore, the sem handle is the value returned from the create function.

```
HEV  hev = 0;
DosOpenEventSem ( "\\SEM32\\MySem", &hev );
```

20SEMA06 930125

DosCloseEventSem

DosCloseEventSem (HEV hev); <-- sem handle

0	NO_ERROR
6	ERROR_INVALID_HANDLE
301	ERROR_SEM_BUSY

- Decrements the open count for the process. If the open count goes to zero (0), the reference count is decremented.
- If the resulting reference count is zero (0), the semaphore is deleted from the system.

20SEMA07 930125

DosPostEventSem, DosResetEventSem

DosPostEventSem (HEV hev); <-- sem handle

0	NO_ERROR
6	ERROR_INVALID_HANDLE
298	ERROR_TOO_MANY_POSTS
299	ERROR_ALREADY_POSTED

- ✓ Asserts the specified event semaphore.
- ✓ Threads blocked on DosWaitEventSem will unblock.

DosResetEventSem (HEV hev, <-- sem handle
PULONG pulPostCt); --> number of posts

0	NO_ERROR
6	ERROR_INVALID_HANDLE
300	ERROR_ALREADY_RESET

- ✓ Negates the specified event semaphore, returns the post count, and resets the post count to zero.
- ✓ Threads issuing a DosWaitEventSem will block.

```
DosResetEventSem ( hev, &ulPostCt );
```

20SEMA08 921020

DosWaitEventSem

```
DosWaitEventSem ( HEV  hev,          <-- event semaphore handle
                  ULONG  ulTimeout ); <-- milliseconds
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
8	ERROR_NOT_ENOUGH_MEMORY
95	ERROR_INTERRUPT
640	ERROR_TIMEOUT

SEM_INDEFINITE_WAIT
SEM_IMMEDIATE_RETURN
or time in milliseconds

- If the event semaphore is in the reset (false) state, this function will block for the specified amount of time.
- If the event semaphore is in the posted (true) state, this function returns immediately.

```
DosWaitEventSem ( hev, 2000 );
```

20SEMA09 930125

DosQueryEventSem

```
DosQueryEventSem ( HEV  hev,                <-- event semaphore handle
                   PULONG  pulPostCt ); --> ptr to returned post count
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
87	ERROR_INVALID_PARAMETER

- Returns the number of times the semaphore has been posted since the last time the semaphore was in the reset state.

```
DosQueryEventSem ( hev, &puPostCt );
```

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DosCreateMutexSem

```
DosCreateMutexSem ( PSZ  pszName,      <-- sem name or zero
                    PHMTX  phmtx,      --> ptr to handle
                    ULONG  flAttr,     <-- create attributes
                    BOOL32  fState );  <-- initial state
```

0	NO_ERROR
8	ERROR_NOT_ENOUGH_MEM0RY
87	ERROR_INVALID_PARAMETER
123	ERROR_INVALID_NAME
285	ERROR_DUPLICATE_NAME
290	ERROR_TOO_MANY_HANDLES

0x01	DC_SEM_SHARED

0x00	FALSE
0x01	TRUE

- Named mutex semaphores (\SEM32\) may be shared between processes by default. Unnamed semaphores may be designated as shared.
- If created in the false state, the semaphore is not owned.
- If created in the true state, the semaphore is owned by the creating thread.

20SEMA11 920728

DosOpenMutexSem

```
DosOpenMutexSem (PSZ  pszName,   <-- sem name or zero
                 PHMTX  phmtx );   <--> sem handle
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
105	ERROR_SEM_OWNER_DIED
123	ERROR_INVALID_NAME
187	ERROR_ERROR_SEM_NOT_FOUND
291	ERROR_TOO_MANY_OPENS

- Makes available for use by the calling process a mutex semaphore that was previously created with the 'share' attribute.
- If opening a named event semaphore, the sem handle should be initialized to zero prior to the open.
- If opening an unnamed event semaphore, the sem handle is the value returned from the create function.

20SEMA12 930628

DosCloseMutexSem

DosCloseMutexSem (HMTX hmtx); <-- sem handle

0	NO_ERROR
6	ERROR_INVALID_HANDLE
301	ERROR_SEM_BUSY

- Invalidates the semaphore handle for the current process and decrements the reference count.
- If the resulting reference count is zero (0), the semaphore is deleted from the system.

20SEMA13 920728

DosRequestMutexSem, DosReleaseMutexSem

```
DosRequestMutexSem ( HMTX  hmtx,          <-- semaphore handle
                     ULONG ulTimeout );   <-- milliseconds
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
95	ERROR_INTERRUPT
103	ERROR_TOO_MANY_SEM_REQUESTS
105	ERROR_SEM_OWNER_DIED
640	ERROR_TIMEOUT

SEM_INDEFINITE_WAIT
SEM_IMMEDIATE_RETURN
or time in milliseconds

```
DosReleaseMutexSem ( HMTX  hmtx );   <-- semaphore handle
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
288	ERROR_NOT_OWNER

- If multiple requests are issued from the same thread, a corresponding number of releases must be issued to relinquish ownerhip of the semaphore

20SEMA14 930901

DosQueryMutexSem

```
DosQueryMutexSem ( HMTX  hmtx,      <-- mutex semaphore handle
                   PPID  ppid,      --> ptr to returned PID of owner
                   PTID  ptid,      --> ptr to returned TID of owner
                   PULONG pulCount ); --> ptr to returned request count
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
87	ERROR_INVALID_PARAMETER
105	ERROR_SEM_OWNER_DIED

- The returned PID and TID identify the current owner of the mutex semaphore or of the previous owner that terminated without releasing the semaphore.
- The request count is the number of requests minus the number of releases.

```
PID pid;
TID tid;
ULONG ulCount;

DosQueryMutexSem ( hmtx, &pid, &tid, &ulCount );
```

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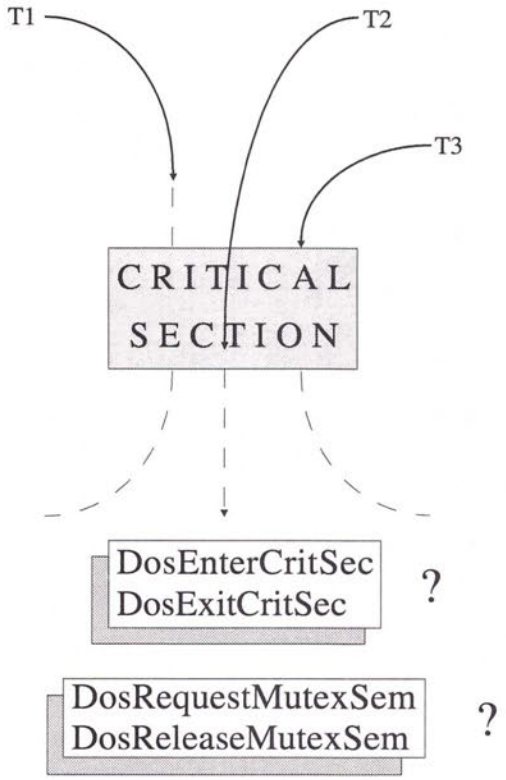
CritSec vs MutexSem



20SEMA16 920722

DosCreateMuxWaitSem

```
DosCreateMuxWaitSem (PSZ  pszName,        <-- sem name or zero
                     PHMUX  phmux,        --> sem handle
                     ULONG  cSemRec,      <-- entry count
                     PSEMRECORD pSemRec,  <-- asr structures
                     ULONG  flAttr );     <-- DC flags
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
100	ERROR_TOO_MANY_SEMAPHORES
105	ERROR_SEM_OWNER_DIED
123	ERROR_INVALID_NAME
284	ERROR_DUPLICATE_HANDLE
285	ERROR_DUPLICATE_NAME
290	ERROR_TOO_MANY_HANDLES
292	ERROR_WRONG_TYPE

0x01	DC_SEM_SHARED
0x02	DCMW_WAIT_ANY
0x04	DCMW_WAIT_ALL

```
typedef struct _PSEMRECORD
{
HSEM hsemCur;
ULONG ulUser;
} SEMRECORD, *PSEMRECORD;
```

- If both event and mutex semaphores are to be monitored, a separate muxwait semaphore must be created for each type.
- If the entry count is zero (0), the pSemRec must also be zero (0).

```
SEMRECORD SemRecs[16];
DosCreateMuxWaitSem ( 0, &hmux, 16, SemRecs, DC_SEM_SHARED | DCMW_WAIT_ANY );
```

20SEMA17 931005

DosOpenMuxWaitSem

```
DosOpenMuxWaitSem (PSZ  pszName,  <-- sem name or zero
                   PHMUX  phmux );  <--> sem handle
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
105	ERROR_SEM_OWNER_DIED
123	ERROR_INVALID_NAME
187	ERROR_ERROR_SEM_NOT_FOUND
291	ERROR_TOO_MANY_OPENS

- ✓ Makes available for use by the calling process a muxwait semaphore that was previously created with the 'share' attribute.
- ✓ If opening a named muxwait semaphore, the sem handle should be zero.
- ✓ If opening an unnamed event semaphore, the sem handle is the value returned from the create function.

20SEMA18 930721

DosCloseMuxWaitSem

DosCloseMuxWaitSem (HMUX hmux); <-- sem handle

0	NO_ERROR
6	ERROR_INVALID_HANDLE
301	ERROR_SEM_BUSY

- Ends access to a muxwait semaphore for all of the threads in the calling process.
- When all processes that opened the semaphore have either closed it or have ended, the semaphore is deleted from the system.

20SEMA19 920722

DosAddMuxWaitSem, DosDeleteMuxWaitSem

```
DosAddMuxWaitSem ( HMUX  hmux,      <-- handle of muxwait semaphore
                   PSEMRECORD  pSemRec );<-- ptr to SemRec to add
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
100	ERROR_TOO_MANY_SEMAPHORES
105	ERROR_SEM_OWNER_DIED
284	ERROR_DUPLICATE_HANDLE
292	ERROR_WRONG_TYPE

```
DosDeleteMuxWaitSem ( HMUX  hmux, <-- mux sem handle
                      HSEM  hsem ); <-- handle of semaphore to be deleted
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
286	ERROR_EMPTY_MUXWAIT

20SEMA20 920722

DosWaitMuxWaitSem

```
DosWaitMuxWaitSem (HMUX  hmux,          <-- mux sem handle
                   ULONG ulTimeout,     <-- milliseconds
                   PULONG pulUser );    --> from PSEMRECORD
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT
103	ERROR_TOO_MANY_SEM_REQUESTS
105	ERROR_SEM_OWNER_DIED
286	ERROR_EMPTY_MUXWAIT
287	ERROR_MUTEX_OWNED
292	ERROR_WRONG_TYPE
640	ERROR_TIMEOUT

-1L	SEM_INDEFINITE_WAIT
0L	SEM_IMMEDIATE_RETURN
or time in milliseconds	

- If the muxwait semaphore was created with the WAIT_ANY option, the SemRecord is from the semaphore that was posted. If mutex semaphores are in the list, the released semaphore will be owned by the caller.
- If the WAIT_ALL option was used, the SemRecord is from the last semaphore posted. If mutex semaphores are in the list, all will be owned by the caller.

20SEMA21 920722

DosQueryMuxWaitSem

```
DosQueryMuxWaitSem (
    HMUX  hmux,              <-- mux sem handle to query
    PULONG  pcSemRec,        <--> ptr to max list size
    PSEMRECORD  pSemRec,     --> ptr to list of semaphores
    PULONG  pflAttr );       -- > DC flags from DosCreateMuxWaitSem
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
105	ERROR_SEM_OWNER_DIED
289	ERROR_PARAM_TOO_SMALL

0x01	DC_SEM_SHARED
0x02	DCMW_WAIT_ANY
0x04	DCMW_WAIT_ALL

- Retrieves the semaphore records from a muxwait semaphore list.
- pSemRec points to a buffer that will receive the semaphore records.
- On input, pcSemRec points to the max number of records pSemRec can hold. On return, it points to the number of records retrieved.

```
ULONG cSemRec = 64;
SEMRECORD semrec[cSemRec];
ULONG flAttr;

DosQueryMuxWaitSem ( hmux, &cSemRec, semrec, &flAttr );
```

20SEMA22 931095

Summary of Semaphore API's

DosCreateMutexSem
DosOpenMutexSem
DosCloseMutexSem
DosRequestMutexSem
DosReleaseMutexSem
DosQueryMutexSem
DosCreateEventSem
DosOpenEventSem
DosCloseEventSem
DosResetEventSem
DosPostEventSem
DosWaitEventSem
DosQueryEventSem
DosCreateMuxWaitSem
DosOpenMuxWaitSem
DosCloseMuxWaitSem
DosWaitMuxWaitSem
DosAddMuxWaitSem
DosDeleteMuxWaitSem
DosQueryMuxWaitSem

20SEMA23 920728

Notes

Timers

Synchronous Timers

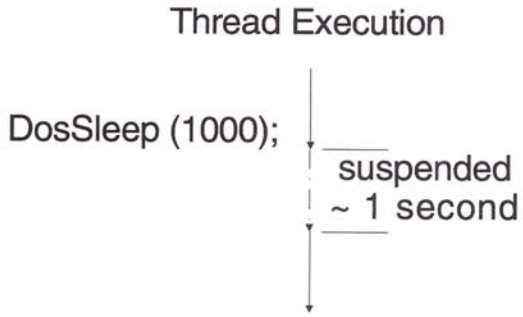
Asynchronous Timers

20TIMR01 921008

DosSleep

DosSleep (ULONG msec); <-- interval in milliseconds

0	NO_ERROR
322	ERROR_TS_WAKEUP



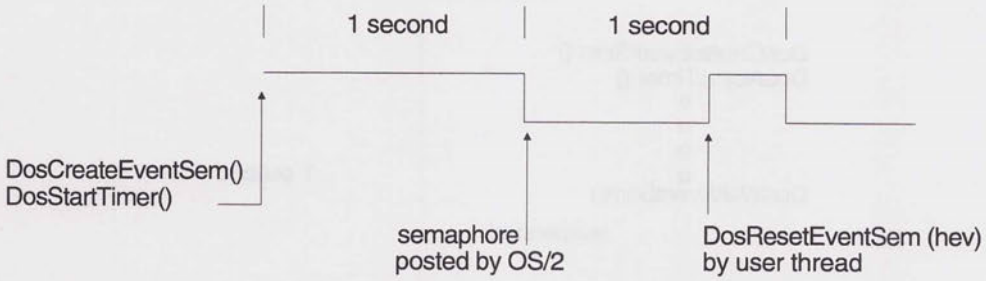
- Suspends the current thread for a specified time interval.
- If the time interval is zero (0), the thread relinquishes the remainder of its time slice to another ready thread of equal or higher priority. If there is no other ready thread of equal or higher priority, the call returns immediately.

20TIMR02 921021

DosStartTimer

```
DosStartTimer (ULONG  msec,      <-- interval in milliseconds
               HEV  hev,         <-- event semaphore handle
               PHTIMER phtimer ); --> timer handle
```

0	NO_ERROR
323	ERROR_TS_SEMHANDLE
324	ERROR_TS_NOTIMER



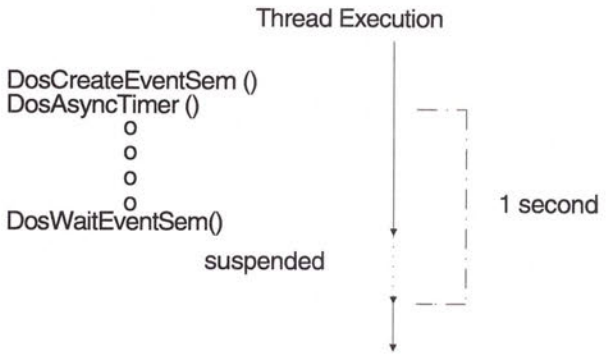
- Starts an asynchronous, repeated-interval timer and post the event semaphore each time the interval expires.
- The returned timer handle is used with DosStopTimer.

20TIMR03 921027

DosAsyncTimer

```
DosAsyncTimer ( ULONG  msec,        <-- interval in milliseconds
                HEV  hev,           <-- event semaphore handle
                PHTIMER phtimer );  --> timer handle
```

0	NO_ERROR
323	ERROR_TS_SEMHANDLE
324	ERROR_TS_NOTIMER



- ✓ Starts an asynchronous, single-interval timer and post the event semaphore when the interval expires.
- ✓ The returned timer handle is used with DosStopTimer.

20TIMR04 921021

DosStopTimer

DosStopTimer (HTIMER htimer); <-- timer handle

0	NO_ERROR
326	ERROR_TS_HANDLE

- Stops either a repeated-interval or single-interval timer.

20TIMR05 920723

Notes

Process Management

Creating Processes

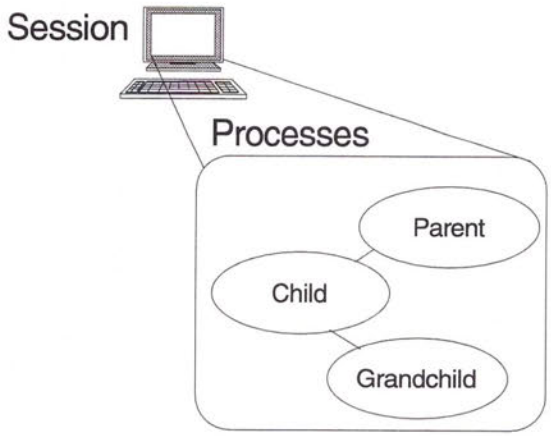
Controlling Processes

Checking Process Status

Performing Cleanup When a Process Ends

20PRCS01 921008

Processes



- A process is created by the invocation of a particular program through the DosExecPgm system call.
- Each process has its own memory, threads, file system and inter-process communication data structures which isolate it from other processes.
- Each process is initially created with a single thread. Additional threads are created through the DosCreateThread system call.

20PRCS02 920729

Process Resources

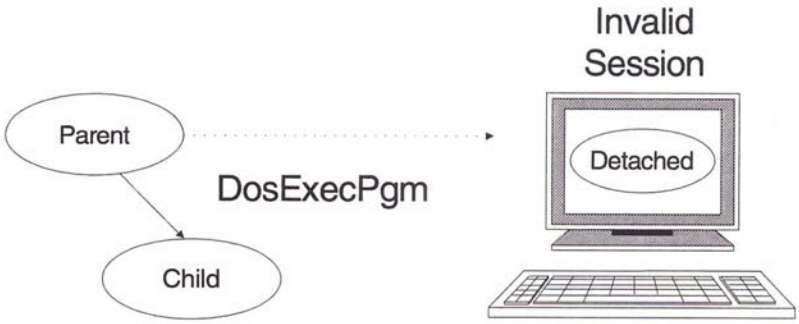
Environment	Semaphores
Commandline	Threads
LDT	Child processes
All allocated segments	Process ID
File handles	Maximum file handle count
Pipes	Default drive, directories
Queues	

- A process is a collection of one or more threads and associated system resources.
- A unit of ownership.
- Can be created at the commandline by:

<program name>	runs in the current session
DETACH <program name>	runs in the Invalid session
START <program name>	runs in a new session

20PRCS03 930125

Creating A Process



- ✓ Processes are created from the command line or under program control with the DosExecPgm.
- ✓ The parent process receives the child process ID number (PID) from the DosExecPgm function.
- ✓ Detached (daemon) processes execute in the Invalid session and may not use standard functions to communicate with the user.

20PRCS04 920729

DosExecPgm

```
DosExecPgm (PCHAR  pObjname,        --> ptr to message buffer
            LONG  cbObjname,        <-- length of message buffer
            ULONG execFlag,         <-- execution flags
            PSZ  pArg,              <-- ptr to argument strings
            PSZ  pEnv,              <-- ptr to environment strings
            PRESULTCODES  pRes, --> ptr to result codes buffer
            PSZ  pName );           <-- ptr to program file name
```

0	NO_ERROR
1	ERROR_INVALID_FUNCTION
2	ERROR_FILE_NOT_FOUND
3	ERROR_PATH_NOT_FOUND
4	ERROR_TO_MANY_OPEN_FILES
5	ERROR_ACCESS_DENIED
8	ERROR_NOT_ENOUGH_MEMORY
10	ERROR_BAD_ENVIRONMENT
11	ERROR_BAD_FORMAT
13	ERROR_INVALID_DATA
26	ERROR_NOT_DOS_DISK
32	ERROR_SHARING_VIOLATION
33	ERROR_LOCK_VIOLATION
36	ERROR_SHARING_BUFFER_EXCEEDED
89	ERROR_NO_PROC_SLOTS
95	ERROR_INTERRUPT
108	ERROR_DRIVE_LOCKED
127	ERROR_PROC_NOT_FOUND
182	ERROR_INVALID_ORDINAL
190	ERROR_INVALID_MODULETYPE
191	ERROR_INVALID_EXE_SIGNATURE
192	ERROR_EXE_MARKED_INVALID
195	ERROR_INVALID_MINALLOCSIZE
196	ERROR_DYNLINK_FROM_INVALID_RING

RETURNED IF EXEC_SYNC ON CHILD TERM.

```
typedef struct _RESULTCODES{
   ULONG codeTerminate;
   ULONG codeResult;
   } RESULTCODES,
    *PRESULTCODES;
```

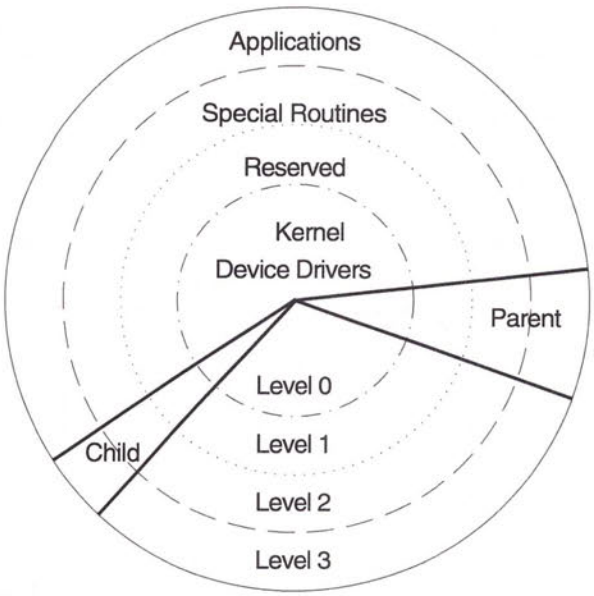
0	EXEC_SYNC ← WAITS TILL CHILD IS DONE
1	EXEC_ASYNC ← PID OF CHILD IS RETURNED
2	EXEC_ASYNCRESULT ← MUST USE THIS IF YOU WANT TO USE: DosWaitChild
3	EXEC_TRACE
4	EXEC_BACKGROUND
5	EXEC_LOAD
6	EXEC_ASYNCRESULTDB

```
DosExecPgm ( Objbuf, 254, EXEC_ASYNCRESULT, 0,
                          0, &Resc, "readfile.exe" );
```

- If the process is executed synchronously, codeTerminate and codeResult are valid upon return from the function.
- If the executed asynchronously, codeTerminate contains the process ID.

20PRCS05 940119

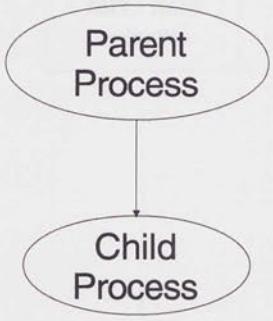
Process Isolation



- ✓ Parent and child processes are isolated by separate page tables and directories.
- ✓ Files and pipes are inherited by the child process.
- ✓ Parent process can control STDIN, STDOUT, and STDERR file handles.

20PRCS 920729

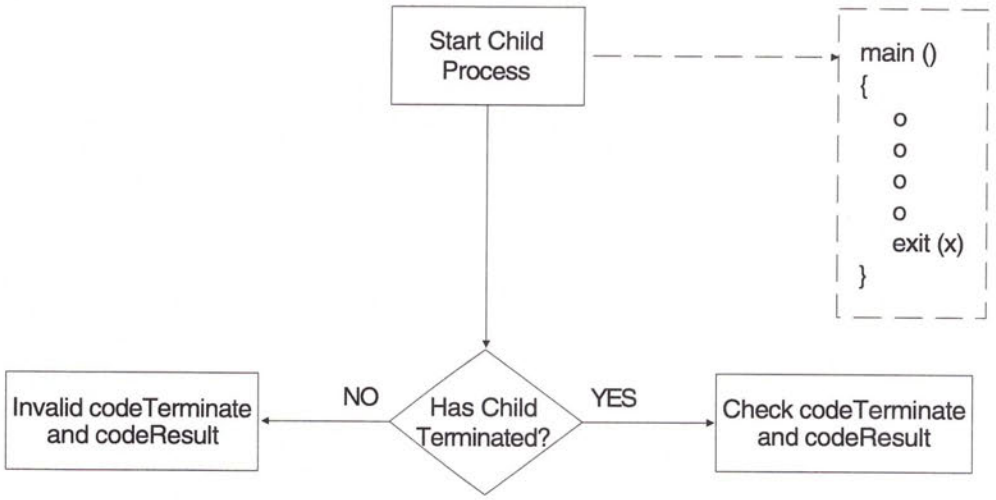
Controlling A Child Process



- After starting a child process, the parent can:
  - terminate the child
  - change the priority of all threads in the child
  - test or wait for child completion

20PRCS07 920729

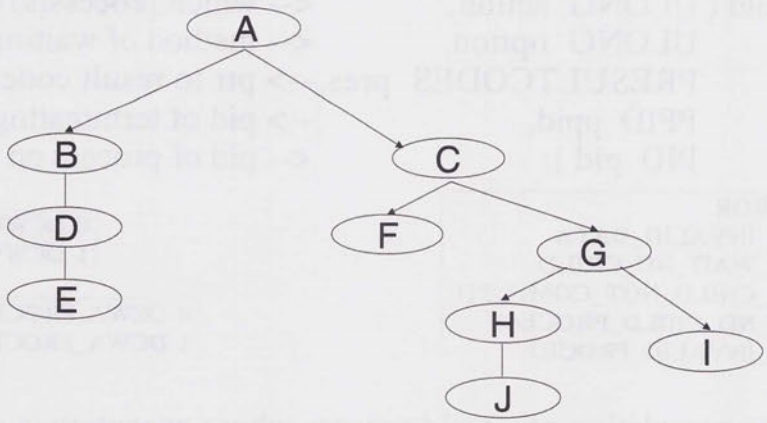
Process Concurrency



- Checking for termination may occur at any time prior to or following the 'exit ()'. codeTerminate and codeResult are only valid after the 'exit ()'.

20PRCS08 920729

Command Subtrees



- DosWaitChild, DosKillProcess and DosSetPriority have two forms:
  - ProcessID - only the direct child is affected
  - Subtree - the direct child and all descendents are affected

20PRCS09 920729

Testing for Child Process Termination

```
DosWaitChild ( ULONG  action,        <-- which process(s) on which to wait
               ULONG  option,        <-- method of waiting
               PRESULTCODES  pres,   --> ptr to result codes
               PPID  ppid,           --> pid of terminating process
               PID  pid );           <-- pid of process on which to wait
```

0	NO_ERROR
13	ERROR_INVALID_DATA
128	ERROR_WAIT_NO_CHILD
129	ERROR_CHILD_NOT_COMPLETE
184	ERROR_NO_CHILD_PROCESS
303	ERROR_INVALID_PROCID

0	DCWW_WAIT
1	DCWW_NOWAIT

0	DCWA_PROCESS
1	DCWA_PROCESSTREE

- Waits for completion of a child process whose execution is asynchronous to that of its parent process.
- The child process is created with the execFlag = EXEC_ASYNCRESULT.
- If the child process has multiple threads, the result code returned is the one passed by the DosExit request that ends the process.

```
DosWaitChild ( DCWA_PROCESS, DCWW_WAIT, &Resc, &pid, Resc.codeTerminate );
```

20PRCS10 940119

DosWaitChild: Process Subtrees

Action Code	Wait Option	PID	Action
DCWA_PROCESSTREE	DCWW_WAIT	n	Wait until the process subtree has completed and then return the direct child's termination code.
DCWA_PROCESSTREE	DCWW_NOWAIT	n	If the process subtree has completed, return the direct child's termination code. Otherwise, return ERROR_CHILD_NOT_COMPLETE. Return Codes: ERROR_WAIT_NO_CHILDREN = 128 ERROR_CHILD_NOT_COMPLETE = 129 NO_ERROR = normal completion; codeTerminate and codeResult are valid

- These will continue to work correctly even if the child process is changed to use more/less child processes of its own.

20PRCS11 920729

DosWaitChild: Individual Processes

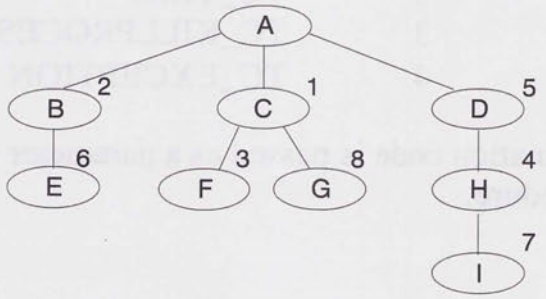
Action Code	Wait Option	PID	Action
DCWA_PROCESS	DCWW_WAIT	0	Returns as soon as ANY direct child process terminates. Returns immediately if child had already terminated.
DCWA_PROCESS	DCWW_WAIT	n	Returns as soon as the direct child 'n' terminates. Returns immediately if child had already terminated.
DCWA_PROCESS	DCWW_NOWAIT	0	Checks for ANY terminated direct child process. If one is found, its status is returned, If none found, returns ERROR_CHILD_NOT_COMPLETE
DCWA_PROCESS	DCWW_NOWAIT	n	Checks the status of direct child 'n'. If terminated, returns its status. If still running, returns ERROR_CHILD_NOT_COMPLETE.

✓ Use these only if the child process is part of the same application as the parent. Parent must know exactly what the child is doing.

20PRCS12 920729

DosWaitChild: Process Subtrees

Action Code	Wait Option	PID	Action
DCWA_PROCESSTREE	DCWW_WAIT	0	Wait until ANY direct child and all of its descendants have terminated. Selects the subtree of the first direct child that terminates.
DCWA_PROCESSTREE	DCWW_NOWAIT	0	Returns error 129 if any process in any subtree is still executing. If all subtrees have terminated, returns direct child's exit code. To wait for all subtrees , repeat call until error code 128 is returned.



20PRCS13 930925

Performing Cleanup When a Process Ends

- For each process, OS/2 maintains a list of procedures that it will call when the process terminates.
- These procedures get control under the following conditions:

Termination Code	Reason
0	TC_EXIT
1	TC_HARDERROR
2	TC_TRAP
3	TC_KILLPROCESS
4	TC_EXCEPTION

- The termination code is passed as a parameter to the Exit List procedure.

20PRCS 920819

Exit List Sequence

```
main ()
{
   DosExitList (0x0100 | EXLST_ADD, (PFNEXITLIST) ShutDown);
   o
   o
   o
   o
   exit (0);
}

void APIENTRY ShutDown (int TermCode)
{
   o
   o
   o
   DosExitList (EXLST_EXIT, 0);
}
```

- Exit list routines should be short and safe.
- The routines can reside in a Dynamic Link Library module.
- Ownership of mutex semaphores is transferred to the thread performing the exit procedure.

20PRCS15 931110

DosExitList

```
DosExitList ( ULONG  ordercode,   <-- function request code
              PFNEXITLIST  pfn ); <-- address of handler
```

0	NO_ERROR
1	ERROR_INVALID_FUNCTION
8	ERROR_NOT_ENOUGH_MEMORY
13	ERROR_INVALID_DATA

Low Word,Low Byte:
- 1 EXLST_ADD
- 2 EXLST_REMOVE
- 3 EXLST_EXIT

Low Word, High Byte:
- Invocation order

High Word = 0

- ✓ Defines a routine(s) (EXLST_ADD) to be given control when a process completes execution.
- ✓ Multiple routines with the same invocation order will be executed in a LIFO order.
- ✓ DosExitList with the 'ordercode' = EXLST_EXIT should be the last function in the exit list routine. This returns control to the kernel.

20PRCS 920729

Shared Memory Objects

Named (Global) Shared Memory

Unnamed (Local) Shared Memory

20SHRM01 920723

Two Types of Shared Objects

- Global (named)

  Use DosAllocSharedMem & DosGetNamedSharedMem.

  Any process that knows the object name may access the object (no IPC required).

- Private (unnamed)

  Use DosAllocSharedMem and DosGiveSharedMem OR DosGetSharedMem.

  Interprocess communication is necessary to pass pointers and PID's.

  Accessibility is limited to participating processes.

20SHRM02 920807

Using Named Shared Objects

Process A

```
memname = \SHAREMEM\MyObj

// create the shared object and
// increment the reference count
DosAllocSharedMem ( ppb, memname, size, allocflg);
        o
        o
        o
// decrement the reference count
DosFreeMem ( pb );
```

Process B

```
memname = \SHAREMEM\MyObj

// enable access to the shared object and
// increment the reference count
DosGetNamedSharedMem ( ppb, memname, flag );
        o
        o
        o
// decrement the reference count
DosFreeMem ( pb );
```

- ✓ Each DosGetNamedSharedMem increments the object's reference count.
- ✓ Each DosFreeMem decrements the reference count.
- ✓ When the reference count = 0, OS/2 discards the object.

NOTE: Process A & B must synchronize so that Process A does not free the object before Process B gets the object.

20SHRM03 920807

Using Unnamed Shared Objects

Process A

```
// allocate the object for sharing
DosAllocSharedMem ( ppb, 0, size, allocflg );
// obtain Process B's PID...
...

; activate the object for Process B
DosGiveSharedMem ( pb, pid, flag );
; pass the pointer to Process B
; using IPC
...
; release the object
DosFreeMem ( pb );
```

Process B

```
// obtain shared object
// pointer via IPC
...
// access the object
...
// release the object
DosFreeMem ( pb );
```

- Each DosGiveSharedMem (DosGetSharedMem) increments the reference count.
- As with named objects, when the reference count = 0, OS/2 discards the object.

NOTE: Process B could use DosGetSharedMem instead. Process A must still pass the pointer to Process B.

20SHRM04 920807

DosAllocSharedMem

```
DosAllocSharedMem ( PPVOID  ppb,      --> address pointer
                    PSZ     pszName,  <-- name or zero
                    ULONG   cb,       <-- size in bytes
                    ULONG   flag );   <-- allocation flags
```

0	NO_ERROR
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT
123	ERROR_INVALID_NAME
183	ERROR_ALREADY_EXISTS

PAG_COMMIT	0x00000010
OBJ_TILE	0x00000040
OBJ_GETTABLE	0x00000100
OBJ_GIVEABLE	0x00000200
fPERM	(PAG_EXECUTE+PAG_READ+PAG_WRITE)
fSHARE	(OBJ_GETTABLE+OBJ_GIVEABLE)
fALLOCSHR	(OBJ_TILE+PAG_COMMIT+fSHARE+fPERM)

```
PVOID  pArray3;
PSZ    pszName = "\\sharemem\\MyObj";
ULONG  ulAllocFlags = PAG_READ | PAG_WRITE | PAG_COMMIT;

DosAllocSharedMem ( &pArray3, pszName, 0x20000, ulAllocFlages );
```

20SHRM05 921021

DosGetNamedSharedMem

```
DosGetNamedSharedMem ( PPVOID  ppb,      --> address pointer
                       PSZ     pszName,  <-- name
                       ULONG   flag );   <-- access requested
```

0	NO_ERROR
2	ERROR_FILE_NOT_FOUND
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT
123	ERROR_INVALID_NAME
212	ERROR_LOCKED

PAG_READ	0x00000001
PAG_WRITE	0x00000002
PAG_EXECUTE	0x00000004
PAG_GUARD	0x00000008
fPERM (PAG_EXECUTE+PAG_READ+PAG_WRITE)	
fGETNMSHR (fPERM)	

- Enables access to a named memory object that was allocated by DosAllocSharedMem.
- The initial call by a process to this function increments the object's reference count.
- At least one process must call this function prior to the allocating process calling DosFreeMem, else the memory object will be released.

```
PSZ pszMemName = "\\sharemem\\MyObj";
PVOID  pArray3;

DosGetNamedSharedMem ( &pArray3, pszMemName, PAG_READ );
```

20SHRM06 930628

DosGiveSharedMem

```
DosGiveSharedMem (PVOID  pb,      <-- identify by address
                  PID  pid,       <-- PID of recipient
                  ULONG  flag );  <-- recipient access rights
```

0	NO_ERROR
5	ERROR_ACCESS_DENIED
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT
212	ERROR_LOCKED
303	ERROR_INVALID_PROCID
487	ERROR_INVALID_ADDRESS

PAG_READ	0x00000001
PAG_WRITE	0x00000002
PAG_EXECUTE	0x00000004
PAG_GUARD	0x00000008
fPERM (PAG_EXECUTE+PAG_READ+PAG_WRITE)	
fGIVESHR (fPERM)	

- Gives another process access to an unnamed memory object allocated 'giveable' with DosAllocSharedMem.
- The initial call by a process to this function increments the object's reference count.

```
DosGiveSharedMem ( pb, pid, PAG_READ | PAG_WRITE );
```

20SHRM07 930628

DosGetSharedMem

```
DosGetSharedMem ( PVOID  pb,          <-- identify by address
                  ULONG  flag );      <-- access flags
```

0	NO_ERROR
5	ERROR_ACCESS_DENIED
8	ERROR_NOT_ENOUGH_MEMORY
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT
212	ERROR_LOCKED

PAG_READ	0x00000001
PAG_WRITE	0x00000002
PAG_EXECUTE	0x00000004
PAG_GUARD	0x00000008
fPERM	(PAG_EXECUTE+PAG_READ+PAG_WRITE)
fGETSHR	(fPERM)

- Enables access to an unnamed memory object that was allocated 'gettable' with DosAllocSharedMem.
- The initial call to this function by a process increments the object's reference count.
- At least one process must call this function prior to the allocating process calling DosFreeMem, else the memory object will be released.

```
DosGetSharedMem ( pb, PAG_READ | PAG_WRITE );
```

20SHRM08 940119

File Input/Output

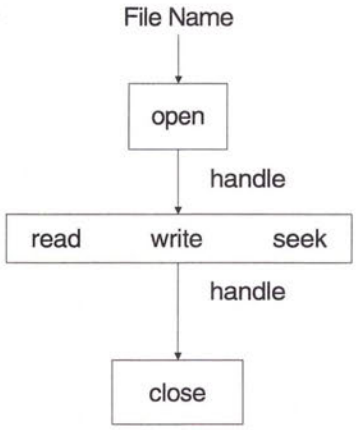
OS/2 File Systems

Opening/Creating/Accessing Files

Standard and Extended File Attributes

20FILE01 920807

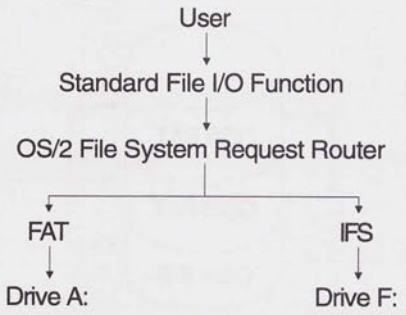
OS/2 File Systems



- Applications use file systems to manage storage devices.
- To an application, files are logical sequences of data.
- File systems manage the physical location of data on the storage device.
- A connection must be established with the file or device to perform input/output.

20FILE02 920807

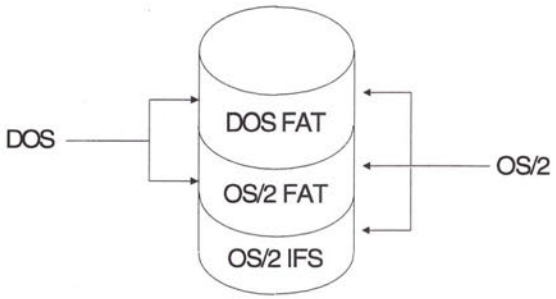
Multiple File Systems



- OS/2 supports the coexistence of mulitple file systems:
  - OS/2 FAT file system similar to DOS (default)
  - Installable File Systems (IFS)
- Each logical device may be managed by a different file system.
- A File System Driver (FSD) must be loaded for each file system other than the FAT system.
- The FSD is installed via the IFS statement in CONFIG.SYS.
- The device is managed by the file system used to format the device.

20FILE03 920807

Recognizing DOS and OS/2 Files



- OS/2 recognizes files created by:
  - DOS FAT file system
  - OS/2 FAT file system
  - Installable File Systems
- DOS recognizes files created by:
  - DOS FAT file system
  - OS/2 FAT file system
- The primary partition must be FAT for dual-booting.

20FILE04 920807

Naming OS/2 Files

- FAT File Systems:
  - 8 character file name
  - 3 character extension
  - Names are case insensitive

- Installable File Systems:
  - Each element of a full path name may be a max of 254 characters.
  - Names are not case sensitive, but case is preserved.
  - Blanks in the middle of a file name are significant.
  - Additional legal characters for file names + - ; , [ ]

```
This.file.name.would.have.been.longer.but,.I.got.tired.of.typing
```

20FILE05 920807

Using Long File Names

- Programs that can handle long file names are marked as being 'long-name-aware'.
- This is done with the Module Definition File by including the NEWFILES statement.
- For compatibility, DLL's should not use or return long file names.
- Files with long names may be moved to non-IFS disks using the File Manager.
- The file name will be truncated to a max of 11 characters and the original long name will be stored in an Extended Attribute.
- When copied back to an IFS drive, the long name will be restored.

20FILE06 920807

Opening/Creating Files

- A file must be opened before it can be accessed.
- The DosOpen function will open an existing file or create a new file.
- The file is opened/created by name and a file handle is returned.
- The handle is used to reference the file in other file system functions.
- When open/creating a file, the caller specifies how the file will be accessed and how it will be shared with other processes.

Access Mode	Share Mode
Read Only	Deny All (no sharing)
Write Only	Deny Read
Read/Write	Deny Write
	Deny None (full sharing)

20FILE07 920807

DosOpen

```
DosOpen (PSZ  pszFileName,      <-- file name
         PHFILE  pHf,           --> ptr to returned file handle
         PULONG  pulAction,     --> ptr to returned action taken
         ULONG  cbFile,         <-- size in bytes for create or replace
         ULONG  ulAttribute,    <-- file attributes
         ULONG  fsOpenFlags,    <-- open flags
         ULONG  fsOpenMode,     <-- open mode
         PEAOP2  peaop2 );      <-- ptr to EA structure
```

0	NO_ERROR
2	ERROR_FILE_NOT_FOUND
3	ERROR_PATH_NOT_FOUND
4	ERROR_TOO_MANY_OPEN_FILES
5	ERROR-ACCESS_DENIED
12	ERROR_INVALID_ACCESS
26	ERROR_NOT_DOS_DISK
32	ERROR_SHARING_VIOLATION
36	ERROR_SHARING_BUFFER_EXCEEDED
82	ERROR_CANNOT_MAKE
87	ERROR_INVALID_PARAMETER
99	ERROR_DEVICE_IN_USE
108	ERROR_DRIVE_LOCKED
110	ERROR_OPEN_FAILED
112	ERROR_DISK_FULL
206	ERROR_FILENAME_EXCED_RANGE
231	ERROR_PIPE_BUSY

0x0000	OPEN_ACCESS_READONLY
0x0001	OPEN_ACCESS_WRITEONLY
0x0002	OPEN_ACCESS_READWRITE
0x0010	OPEN_SHARE_DENYREADWRITE
0x0020	OPEN_SHARE_DENYWRITE
0x0030	OPEN_SHARE_DENYREAD
0x0040	OPEN_SHARE_DENYNONE
0x0080	OPEN_FLAGS_NOINHERIT
0x0000	OPEN_FLAGS_NO_LOCALITY
0x0100	OPEN_FLAGS_SEQUENTIAL
0x0200	OPEN_FLAGS_RANDOM
0x0300	OPEN_FLAGS_RANDOMSEQUENTIAL
0x1000	OPEN_FLAGS_NO_CACHE
0x2000	OPEN_FLAGS_FAIL_ON_ERROR
0x4000	OPEN_FLAGS_WRITE_THROUGH
0x8000	OPEN_FLAGS_DASD

0x1	FILE_EXISTED
0x2	FILE_CREATED
0x3	FILE_REPLACED

0x0	FILE_NORMAL
0x1	FILE_READONLY
0x2	FILE_HIDDEN
0x4	FILE_SYSTEM
0x10	FILE_DIRECTORY
0x20	FILE_ARCHIVED

0x00	OPEN_ACTION_FAIL_IF_EXISTS
0x01	OPEN_ACTION_OPEN_IF_EXISTS
0x02	OPEN_ACTION_REPLACE_IF_EXISTS
0x00	OPEN_ACTION_FAIL_IF_NEW
0x10	OPEN_ACTION_CREATE_IF_NEW

```
DosOpen ( "TestFile", &Hf, &ulAction, 0, FILE_NORMAL, OPEN_ACTION_OPEN_IF_EXITS,
                                OPEN_ACCESS_READONLY | OPEN_SHARE_DENYWRITE, 0 );
```

20FILE08 921021

Synchronous File Input/Output

```
DosRead [Write] (HFILE  hFile,              <-- open file handle
                 PVOID  pBuffer,            <-- ptr to data buffer
                 ULONG  cbRead [Write],     <-- # of bytes to transfer
                 PULONG pcbActual );        --> ptr to returned actual bytes
```

0	NO_ERROR
5	ERROR_ACCESS_DENIED
6	ERROR_INVALID_HANDLE
19	ERROR_WRITE_PROTECT
26	ERROR_NOT_DOS_DISK
29	ERROR_WRITE_FAULT
33	ERROR_LOCK_VIOLATION
109	ERROR_BROKEN_PIPE
234	ERROR_MORE_DATA

- ✓ DosRead (Write) automatically moves the file pointer.
- ✓ Reading and writing 512 bytes at a time (sector size) will speed up the processing
- ✓ If read returns cbActual = 0, end of file was reached.
- ✓ Standard device handle values:

  0= STDIN 1 = STDOUT 2 = STDERR

20FILE09 921021

Asynchronous File Input/Output

```
typedef struct _RW
{
HFILE  hFile;
PVOID  pBuffer;
ULONG cb;
PULONG  pcbActual;
APIRET  rc;
HEV  hev;
} RW, *PRW;
int main ( void ){
RW  rw;
DosCreateEventSem ();
DosCreateThread ( ptid, AsyncRW, &rw, ready, 16384 );

Other Processing

DosWaitEventSem ( )
if (rw.rc) terminate;

Data is Valid
}
```

```
AsyncRW ( PRW prw )
{
prw->rc = DosRead ( prw->hFile,
                    prw->pBuffer,
                    prw->cb,
                    prw->pcbActual );

DosPostEventSem ();
}
```

- The event semaphore is posted when the read or write is completed.
- main must wait until the semaphore is posted to access the data in the buffer.

20FILE10 930903

Changing the Size of a File

```
DosSetFileSize (HFILE hFile,      <-- open file handle
                ULONG cbSize );<-- size in bytes
```

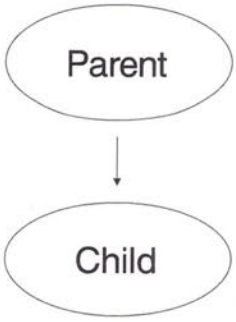
0	NO_ERROR
5	ERROR_ACCESS_DENIED
6	ERROR_INVALID_HANDLE
26	ERROR_NOT_DOS_DISK
33	ERROR_LOCK_VIOLATION
87	ERROR_INVALID_PARAMETER
112	ERROR_DISK_FULL

- ✓ Changes the amount of space allocated to a file.
- ✓ The file must be opened for write access.
- ✓ The file can be truncated or extended in size. If extended, the value of the new bytes is undefined.

```
DosSetFileSize ( hf, 50000 );
```

20FILE11 921021

Inheriting Files



- If the parent opens a file with the inheritance option, then that file handle may be used by the child process.
- All sharing and access modes are preserved.
- Processes own files, threads do not. Any thread in a process can read from a file, even if it is not shared.

20FILE12 920808

Locking Regions of a File

```
DosSetFileLocks (HFILE  hfile,          <-- open file handle
                 PFILELOCK  pflUnlock,  <-- ptr to unlock range
                 PFILELOCK  pflLock,    <-- ptr to lock range
                 ULONG  timeout,        <-- time in milliseconds
                 ULONG  flags );        <-- atomic/share flags
```

0	NO_ERROR
6	ERROR_INVALID_HANDLE
33	ERROR_LOCK_VIOLATION
36	ERROR_SHARING_BUFFER_EXCEEDED
87	ERROR_INVALID_PARAMETER
95	ERROR_INTERRUPT
174	ERROR_ATOMIC_LOCK_NOT_SUPPORTED
175	ERROR_READ_LOCKS_NOT_SUPPORTED

```
_typedef struct _FILELOCK {
   LONG  lOffset
   LONG  lRange
} FILELOCK, *PFILELOCK
```

0x1	Share for read-only
0x2	Atomic lock

- ✓ A process may temporarily be prohibited from accessing certain areas of a file that was opened for sharing by another process.
- ✓ If processes are not accessing the same region at the same time, they both operate in parallel.
- ✓ Locked regions are not inherited from the parent process.

```
FILELOCK  filelock;

filelock.lOffset = 1500;
filelock.lRange = 250;
DosSetFileLocks ( hFile, 0, &filelock, 300, 0 );
```

20FILE13 921021

Updating File Data/Directory

DosClose (HFILE hFile); <-- open file handle

DosResetBuffer (HFILE hFile); <-- open file handle

0 NO_ERROR
2 ERROR_FILE_NOT_FOUND
5 ERROR_ACCESS_DENIED
6 ERROR_INVALID_HANDLE

- DosClose flushes the internal buffers, updates the directory and invalidates the file handle for the calling process.
- DosResetBuffer flushes internal buffers and updates thedirectory without closing file. If the file handle 0xFFFF is specified, all buffers for all files open to the process are flushed.

20FILE14 921008

Standard File Attributes

Date and Time of Creation
Date and Time of Last Access
Date and Time of Last Write
File Size
Allocated File Size
File Attributes

- This is referred to as Level 1 File Information..
- The DIR command displays a subset of this information.
- An application may request Level 1 information with the DosQueryFileInfo or DosQueryPathInfo functions.

20FILES15 920808

Extended File Attributes

- Extended Attributes (EAs) may be used to describe a file to another application, the operating system or the file system.
- EAs may be used for such things as:

  Store notes such as the creator of a file
  Catagorize files such as source, icons, bit maps, etc.
  Describe the format of data in a file
  Append additional data to a file

- EAs are not part of the file data but, are maintained by the file system.
- More than one EA may be associated with a file.
- Each EA consist of an ASCII Name and a Value of any data type.
- The maximum size of each EA is 64Kb.
- EAs are classified as critical or non-critical.

20FILE16 920808

Naming Extended Attributes

- Application specific EAs should be prefixed with the company name and product name.

  Company - IBM
  Product - DisplayWrite
  Attribute - Stuff
  EA Name = IBM_DW.Stuff

- A set of Standard Extended Attributes (SEAs) define common info associated with a file.

- SEA names are prefixed with a period (.).

  .TYPE
  .KEYPHRASES
  .SUBJECT
  .COMMENTS
  .HISTORY
  .VERSION
  .LONGNAME
  .ICON
  .ASSOCTABLE
  .CODEPAGE

- Reserved prefixes are $ @ & +

20FILE17 920808

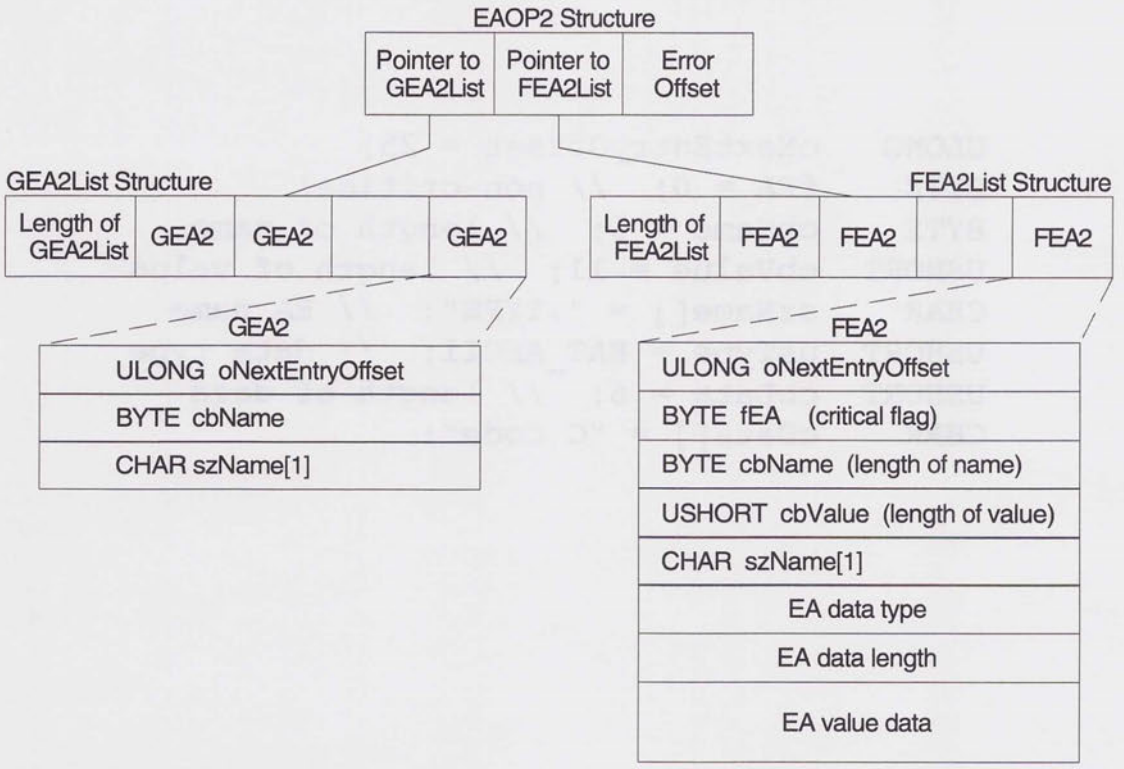
Extended Attribute Data Types

Description	Data Type	Constant
Length-preceded binary	FFFE	EAT_BINARY
Length-preceded ASCII	FFFD	EAT_ASCII
Length-preceded bitmap	FFFB	EAT_BITMAP
Length-preceded metafile	FFFA	EAT_METAFILE
Length-preceded icon	FFF9	EAT_ICON
ASCII EA name of associated data	FFEE	EAT_EA
Multi-valued, multi-typed data	FFDF	EAT_MVMT
Multi-valued, single-typed data	FFDE	EAT_MVST
ASN.1 field	FFDD	EAT_ASN1
Reserved	8000-FFDC	
User-definable	0000-7FFF	

- ✓ The Value of an EA may be any type of data.
- ✓ The first word of the EA data should indicate the data type.

20FILE18 920808

Extended Attribute Data Structures



20RLE19

Example of a Single-Value EA

```
ULONG   oNextEntryOffset = 25;
BYTE    fEA = 0;  // non-critical
BYTE    cbName = 5;  // length of name
USHORT  cbValue = 11;  // length of value
CHAR    szName[] = ".TYPE";  // EA name
USHORT  usType = EAT_ASCII;  // data type
USHORT  cbData = 6;  // length of data
CHAR    cData[] = "C Code";
```

20FILE20 930211

Example of a Multi-Value, Single-Type EA

```
ULONG   oNextEntryOffset = 56;
BYTE    fEA = 0;  // non-critical
BYTE    cbName = 16;  // length of name
USHORT  cbValue = 31;  // length of value
CHAR    szName[] = "PCRI_SAMPLE.MVST";  // EA name
USHORT  usType = EAT_MVST;
USHORT  usCodePage = 0;  // use default
USHORT  usNumEntries = 3;  // number of entries
USHORT  usDataType = EAT_ASCII;
USHORT  cbData1 = 5;  // length of 1st entry
CHAR    cData1[] = "Hello";
USHORT  cbData2 = 4;
CHAR    cData2[] = "OS/2";
USHORT  cbData3 = 5;
CHAR    cData3[] = "World";
```

20FILES21 930211

Example of a Multi-Value, Multi-Type EA

```
ULONG   oNextEntryOffset = 55;
BYTE    fEA = 0;  // non-critical
BYTE    cbName = 16;  // length of name
USHORT  cbValue = 30;  // length of value
CHAR    szName[] = "PCRI_SAMPLE.MVST";  // EA name
USHORT  usType = EAT_MVMT;
USHORT  usCodePage = 0;  // use default
USHORT  usNumEntries = 2;  // number of entries
USHORT  usDataType = EAT_ASCII;
USHORT  cbData1 = 11;  // length of 1st entry
CHAR    cData1[] = "Hello World";
USHORT  usDataType = EAT_BINARY;
USHORT  cbData2 = 4;
BYTE    bData2[4] = {0x68, 0x65, 0x6c, 0x6f};
```

20FILE22 930211

Preserving EAs

- Non-EA aware programs may not open files with CRITICAL EAs except for replacement.
- Files with non-critical EAs may be accessed by non-EA aware programs.
- EA-aware programs do not have any restrictions.
- EAs may be lost when files are:
  - Transferred to a down-level system
  - Opened for replacement by non-EA aware programs
  - Sent over comm lines
- The EAUTIL program allows EAs to be handled separately from the associated file.
- EAs may be stripped and placed in a separate file and then reattached to the associated file.

20FILE23 920808

Managing EAs

- EAs may be defined when a file/subdirectory is created with DosOpen/DosCreateDir.
- EAs may be defined for existing files with DosSetFileInfo or DosSetPathInfo.
- EAs may be examined with DosQueryFileInfo, DosQueryPathInfo or DosEnumAttribute.
- Files with specific EAs may be searched with DosFindFirst and DosFindNext.

20FILE24 920808

Queues

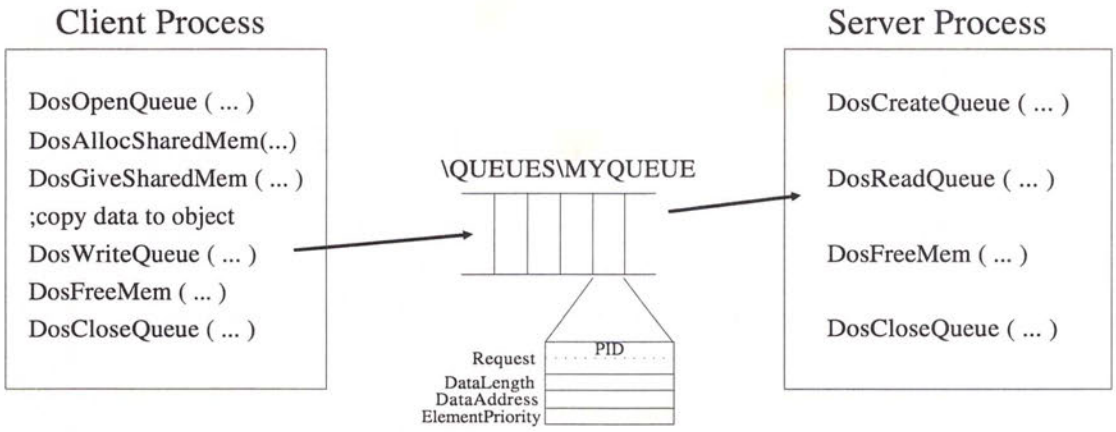
Creating/Peeking/Reading Queues From A Server Process

Opening/Writing/Closing Queues From A Client Process

Monitoring Multiple Queues From A Server Process

20QUES01 920810

Queue Overview



- ✓ Only the queue creator may read the queue.
- ✓ The Client process allocates the shared object and passes the pointer and size to the Server process through the queue.
- ✓ You could also use 'named' shared objects and the suballocation API's instead of DosGiveSharedMem.

20QUES02 920810

DosCreateQueue

```
DosCreateQueue (PHQUEUE  phq,     -> r/w queue handle
                ULONG  priority,  <- QUE_ constants
                PSZ  pszName );   <- \QUEUES\...
```

0	NO_ERROR
87	ERROR_INVALID_PARAMETER
332	ERROR_QUE_DUPLICATE
334	ERROR_QUE_NO_MEMORY
335	ERROR_QUE_INVALID_NAME

0L	QUE_FIF0
1L	QUE_LIFO
2L	QUE_PRIORITY
4L	QUE_CONVERT_ADDRESS

- ✓ The process creating a queue is the server.
- ✓ Processes opening the queue are clients.

```
HQUEUE  hq;
DosCreateQueue ( &hq, QUE_LIFO, "\\queues\\MyQue" );
```

20QUES03 931119

DosOpenQueue

```
DosOpenQueue ( PPID  ppid,          -> pid of server
               PHQUEUE  phq,        -> write queue handle
               PSZ pszName );       <- \QUEUES\...
```

0	NO_ERROR
334	ERROR_QUE_NO_MEMORY
341	ERROR_QUE_PROC_NO_ACCESS
343	ERROR_QUE_NAME_NOT_EXIST

✓ Enables access to a previously created queue.

```
DosOpenQueue ( &pid, &hq, "\\queues\\MyQue" );
```

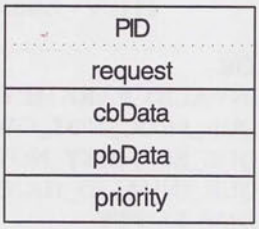
20QUES04 921021

* you need the PID of server in order to set up giveable memory to share with server.

DosWriteQueue

```
DosWriteQueue ( HQUEUE  hq,        <- queue handle
                ULONG   request,   <- 32-bit application specific
                ULONG   cbData,    <- data size
                PVOID   pbData,    <- data pointer
                ULONG   priority ); <- priority value, 15=high, 0=low
```

0	NO_ERROR
334	ERROR_QUE_NO_MEMORY
337	ERROR_QUE_INVALID_HANDLE




```
DosWriteQueue ( hq, 0x1ff, 2000, pBuffer, 0 );
```

20QUES05 921021

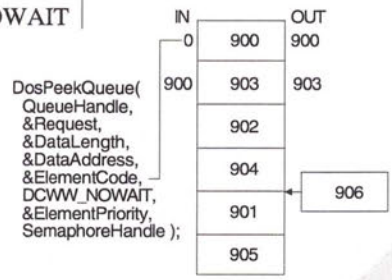
DosPeekQueue

```
DosPeekQueue ( HQUEUE  hq,          <- queue handle
               PREQUESTDATA pRequest,-> clients pid and request
               PULONG  pcbData,     -> data size
               PPVOID  ppbuf,       -> data address
               PULONG  element,     <-> 0 input, peek 1st element
                                        N output, specific element
               BOOL32  nowait,      <- DCWW_ parameter
               PBYTE   ppriority,   -> priority value
               HEV     hsem );      <- event semaphore handle
```

```
0   NO_ERROR
87  ERROR_INVALID_PARAMETER
330 ERROR_QUE_PROC_NOT_OWNED
333 ERROR_QUE_ELEMENT_NOT_EXIST
337 ERROR_QUE_INVALID_HANDLE
342 ERROR_QUE_EMPTY
433 ERROR_QUE_INVALID_WAIT
```

```
typedef struct _REQUESTDATA
{
PID  pid;
ULONG  ulData;
} REQUESTDATA, *PREQUESTDATA;
```

```
0 DCWW_WAIT
1 DCWW_NOWAIT
```



20QUES06 921027

DosReadQueue

```
DosReadQueue ( HQUEUE  hq,          <- queue handle
               PREQUESTDATA pRequest, -> clients pid and request
               PULONG  pcbData,     -> data size
               PPVOID  ppbuf,       -> data address
               ULONG  element,      <- element code
               BOOL32  wait,        <- DCWW_ parameter
               PBYTE  ppriority,    -> priority value
               HEV  hsem );         <- event semaphore handle
```

```
0   NO_ERROR
87  ERROR_INVALID_PARAMETER
330 ERROR_QUE_PROC_NOT_OWNED
333 ERROR_QUE_ELEMENT_NOT_EXIST
337 ERROR_QUE_INVALID_HANDLE
342 ERROR_QUE_EMPTY
433 ERROR_QUE_INVALID_WAIT
```

```
typedef struct _REQUESTDATA
{
PID  pid;
ULONG  ulData;
} REQUESTDATA, *PREQUESTDATA;
```

```
0 DCWW_WAIT
1 DCWW_NOWAIT
```

```
DosReadQueue ( hq, &Request, &cbData, &pbuf, 0, DCWW_NOWAIT, &pri, hev );
```

20QUES07 921027

DosQueryQueue, DosPurgeQueue, DosCloseQueue

```
DosQueryQueue (HQUEUE  hq,          <- queue handle
               PULONG  pcbEntries ); -> number of queue elements
```

0 NO_ERROR
337 ERROR_QUE_INVALID_HANDLE

```
DosPurgeQueue (HQUEUE  hq );   <- queue handle
```

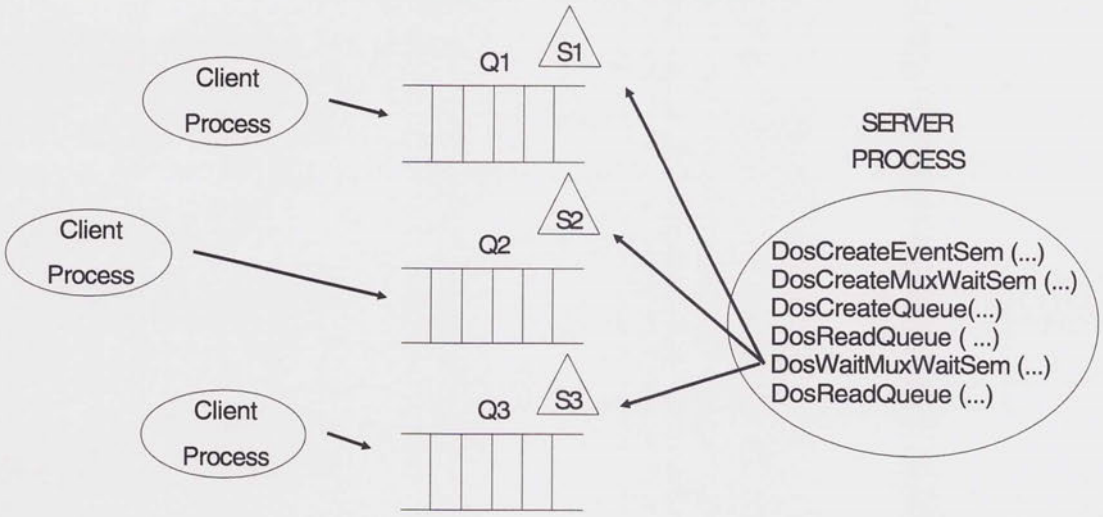
0 NO_ERROR
330 ERROR_QUE_PROC_NOT_OWNED
337 ERROR_QUE_INVALID_HANDLE

```
DosCloseQueue (HQUEUE  hq );   <- queue handle
```

0 NO_ERROR
337 ERROR_QUE_INVALID_HANDLE

20QUES08 920810

Monitoring Mutiple Queues



- ✓ Allows the monitoring of multiple queues by the server process.
- ✓ When a client writes to the queue, the event semaphore will automatically be opened and posted.
- ✓ The server could query the event semaphore to determine the number of posts issued.

20ques09 920810

Notes

Dynamic Link Libraries

Static Linking

Dynamic Linking

Building a Dynamic Link Library

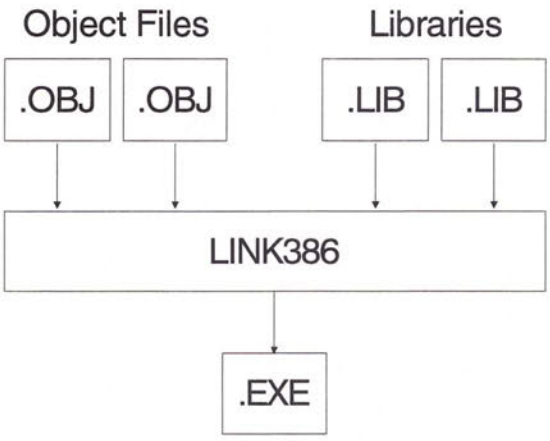
Dynamic Linking at Run Time

DLL Initialization

20DLLS01 920814

SEE DDL.4 in supplmental handbook

Static Linking



- All object file and library file code and data are in the .EXE even if not all will be used.

20DLLS02 920811

Disadvantages of Static Linking

- ⊘ All of the target code and data must be available at link time.
- ⊘ All modules must be re-linked if the target code changes.
- ⊘ The target code can not be shared among applications.
- ⊘ The operating system may have multiple copies of the same code/data in memory and on the disk.
- ⊘ The executable (.EXE) files are large.

20DLLS02 920811

Advantages and Disadvantages of Dynamic Link Libraries

- Advantages:

  OS/2 only keeps one copy of the code in memory.

  Upgrades are easier; simply replace the DLL.

  Dynlink procedures can call other dynlink procedures.

  .EXE files are smaller.

- Disadvantage:

  Program loading may take longer.

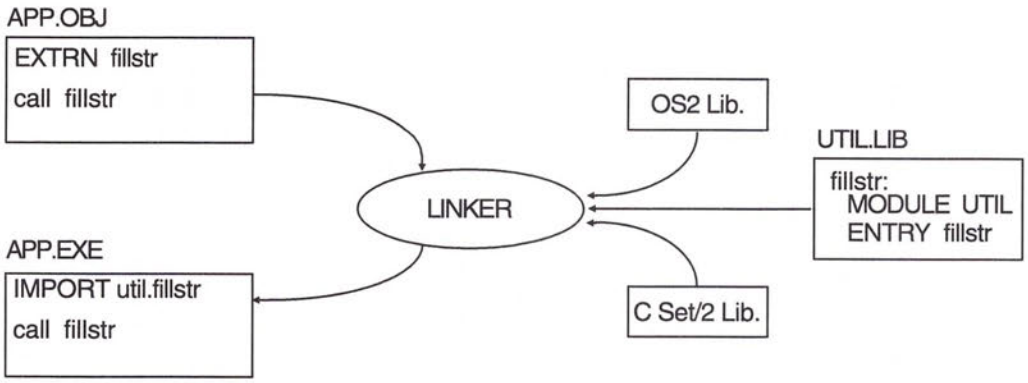
20DLLS04 920814

Dynamic Links vs Processes

- OS/2 views dynlinks as subroutines, not as separate processes.
- The dynlink procedure runs in the context of its calling thread and process .
- Dynlink calls are fast since there is no change in the privilege level.
- Dynlink objects are mapped to the same linear addresses for all processes.

20DLLS05 930910

Dynamic Linking



- The program makes an external reference to a procedure:

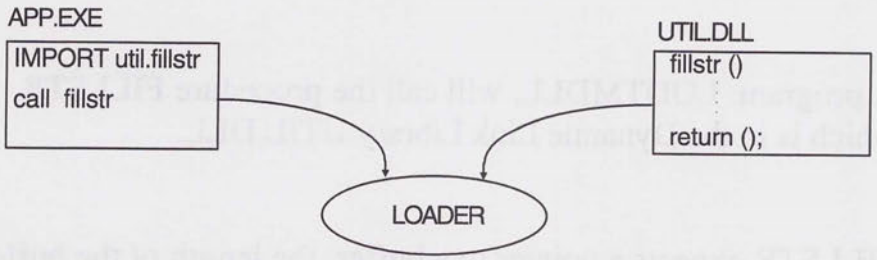
  EXTERN USHORT APIENTRY fillstr (PSZ pszBuff, USHORT usLength, CHAR chFill);

- The object file is linked to a special library file that contains the module name where the procedure 'fillstr' lives (UTIL).

- The APP.EXE file does NOT contain the target Code or Data.

20DLLS06 920905

Load Time



- The OS/2 loader brings in the target code and fixes up the call.
- 'fillstr' runs as a near procedure.
- The Dynamic Link Library file (DLL) contains the code for 'fillstr'.

20DLLS07 920814

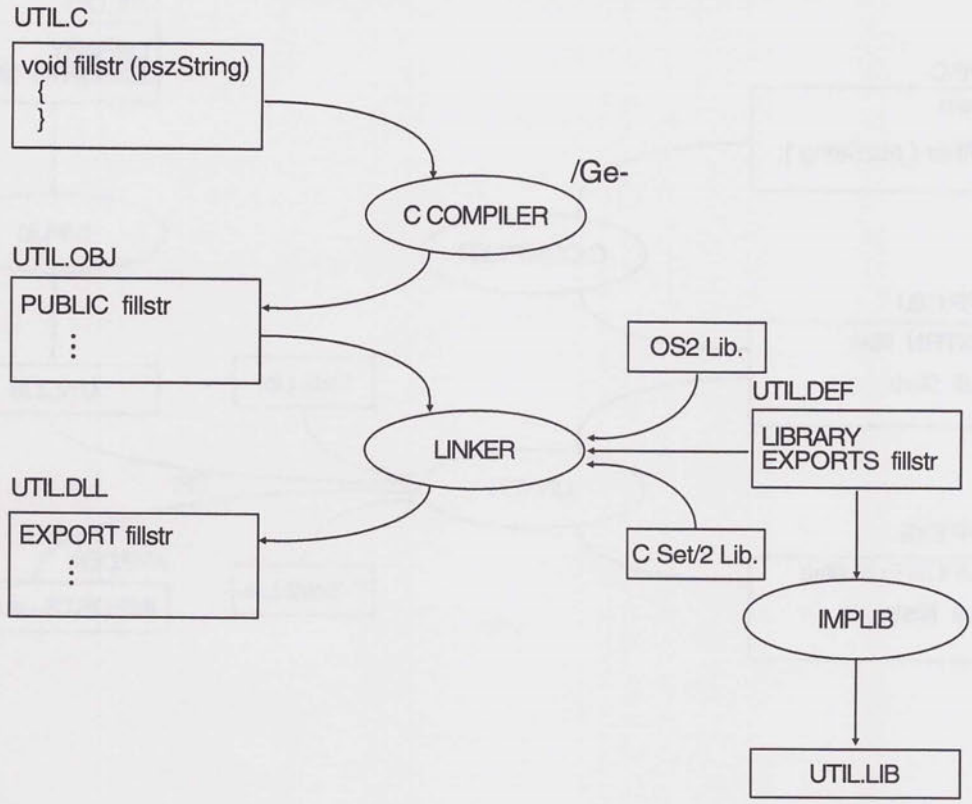
Building a DLL

- A program, LODTMDLL, will call the procedure FILLSTR which is in the Dynamic Link Library UTIL.DLL.

- FILLSTR expects a pointer to a buffer, the length of the buffer and the character with which to fill the buffer.

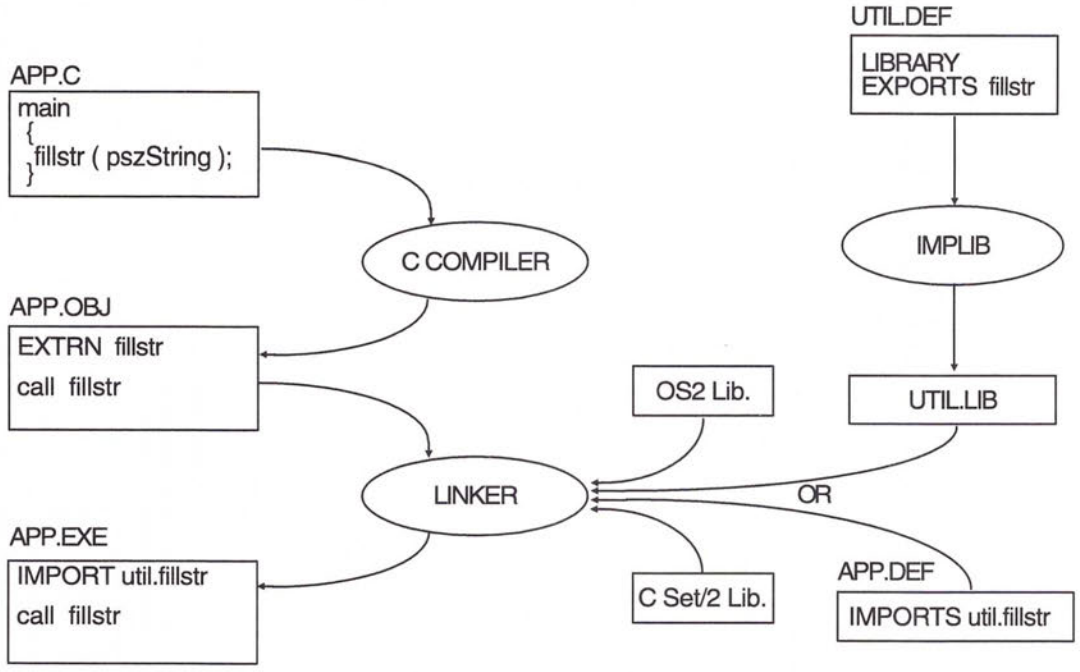
20DLLS08 920812

Preparing the .DLL and Import Library



20DLLS09 930325

Preparing the .EXE

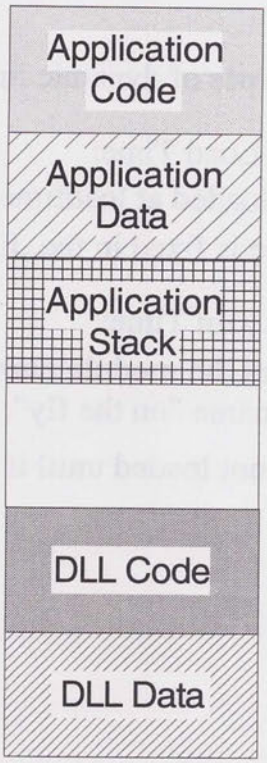


20DLL10 940125

Variables in Main and in the DLL

```
CHAR a;
main (void)
  CHAR b;
  static CHAR c;

  dllsub ( a, b, c );
```




```
CHAR dlldata[28];
dllsub ( CHAR a, CHAR b, CHAR c)
    {
    CHAR dlla;
    a = 'x';
```

20DLLS15 920925

Methods of Dynamic Linking

- OS/2 supports two types of dynamic linking.
- Dynamic Linking at Load Time:
  - Target code is loaded at loadtime.
  - Procedure name is fixed in the .EXE file.
- Dynamic Linking at Run Time:
  - Program creates the module name and the procedure name "on the fly".
  - Target code is not loaded until it is needed.

20DLLS16 920812

Dynamic Linking at Run Time

- The process creates the module and procedure name.
- The process then calls DosLoadModule to find and load the target DLL module.
- A call to DosQueryProcAddr returns a pointer to the target procedure.
- The procedure is invoked directly through the pointer.
- When done, the process calls DosFreeModule to release the DLL module.

20DLLS17 921008

DosLoadModule

```
DosLoadModule (PSZ  pszName,        --> ptr to msg. buffer
               ULONG  cbName,       <-- size of msg. buffer
               PSZ  pszModname,     <-- name of module to load
               PHMODULE  phmod ); --> ptr to returned module handle
```

0	NO_ERROR	127	ERROR_PROC_NOT_FOUND
2	ERROR_FILE_NOT_FOUND	180	ERROR_INVALID_SEGMENT_NUMBER
3	ERROR_PATH_NOT_FOUND	182	ERROR_INVALID_ORDINAL
4	ERROR_TOO_MANY_OPEN_FILES	190	ERROR_INVALID_MODULETYPE
5	ERROR_ACCESS_DENIED	191	ERROR_INVALID_EXE_SIGNATURE
8	ERROR_NOT_ENOUGH_MEMORY	192	ERROR_EXE_MARKED_INVALID
11	ERROR_BAD_FORMAT	194	ERROR_ITERATED_DATA_EXCEEDS_64K
26	ERROR_NOT_DOS_DISK	195	ERROR_INVALID_MINALLOCSIZE
32	ERROR_SHARING_VIOLATION	196	ERROR_DYNLINK_FROM_INVALID_RING
33	ERROR_LOCK_VIOLATION	198	ERROR_INVALID_SEGDPL
36	ERROR_SHARING_BUFFER_EXCEEDED	199	ERROR_AUTODATASEG_EXCEEDS_64K
95	ERROR_INTERRUPT	201	ERROR_RELOCSCR_CHAIN_EXCEEDS_SEGLIMIT
108	ERROR_DRIVE_LOCKED	206	ERROR_FILENAME_EXCED_RANGE
123	ERROR_INVALID_NAME	295	ERROR_INIT_ROUTINE_FAILED

```
DosLoadModule ( &Msgbuf, 254, "MYDLL", &hmod );
```

DosQueryProcAddr, DosFreeModule

DosQueryProcAddr (HMODULE hmod, <-- module handle
ULONG ordinal, <-- ordinal number
PSZ pszName, <-- procedure name
PFN *ppfn); --> ptr to returned proc addr

```
    0 NO_ERROR
    6 ERROR_INVALID_HANDLE
  123 ERROR_INVALID_NAME
65079 ERROR_ENTRY_IS_CALLGATE
```

```
void ( *pfnReport) (PSZ pszMsg, APIRET rc, PSZ MyName );

rc = DosQueryProcAddr ( hmod, 0, "report", (PFN *) &pfnReport );
if (rc) exit (1);
pfnReport ("QueryProcAddress successful!\n", 0, "INFOMSG: " );
```

DosFreeModule (HMODULE hmod); <-- module handle

```
 0 NO_ERROR
 6 ERROR_INVALID_HANDLE
12 ERROR_INVALID_ACCESS
95 ERROR_INTERRUPT
```

20DLLS19 940119

Data Objects in DLLs

- Regular .EXE programs get unique copies of all data objects whenever the .EXE file is loaded (default).

- DLL modules do NOT. The loader will only load one copy of the data objects for DLL modules by default.

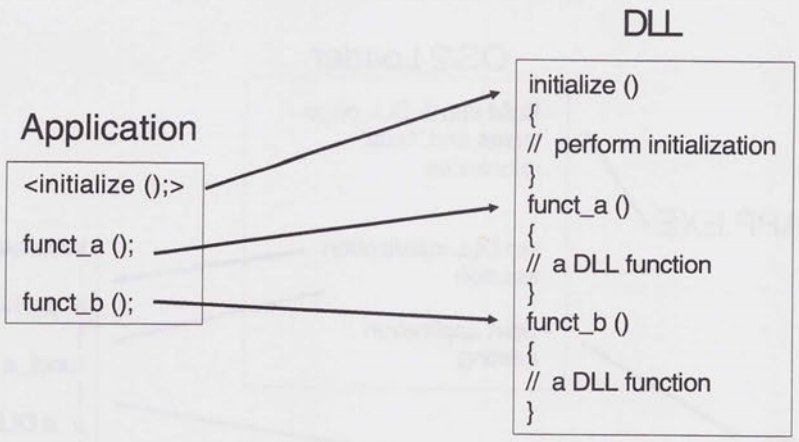
- This may be overridden with an entry in the module definition file:

  ```
  DATA  MULTIPLE  NONSHARED
  ```

- DLL's use the stack memory of the calling process.

20DLLS20 921008

DLL Initialization

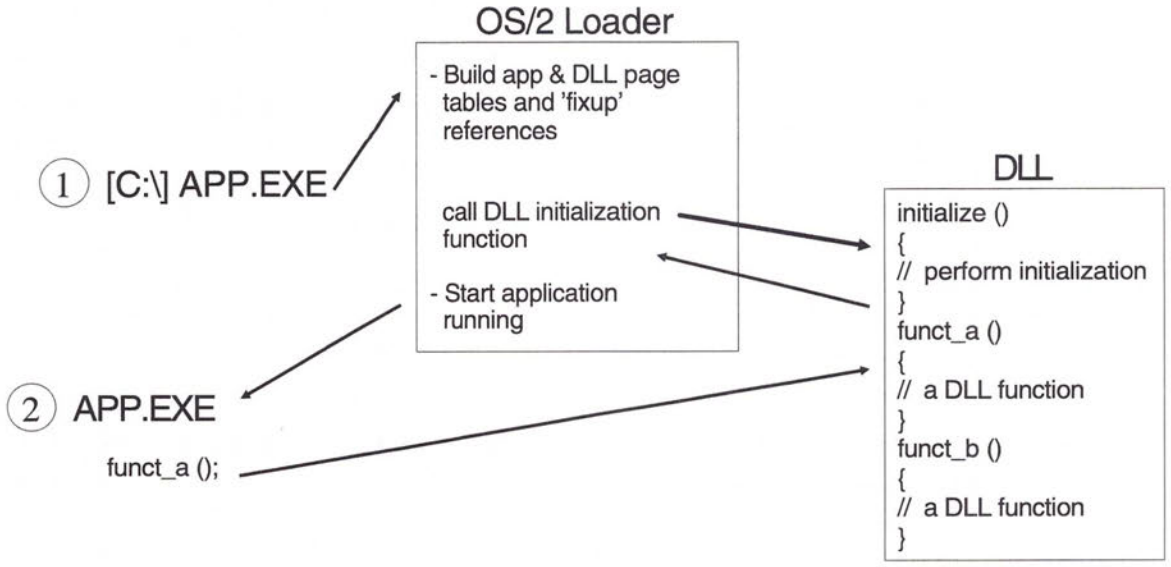


- A DLL may need to perform initialization functions before the application invokes any procedures in the DLL.

- The initialization may involve:
  - allocating memory
  - creating or opening files
  - setting up devices

20DLLS21 920812

Flow of Control for DLL Initialization



- The loader calls the DLL's initialization function before the application can call other DLL functions. This will also occur during DosLoadModule.

20DLLS22 921008

_DLL_InitTerm

unsigned long _DLL_InitTerm (unsigned long modhandle, --> DLL file handle
unsigned long flag); --> 0=init, 1=term

```
#pragma linkage ( _DLL_InitTerm, system)
int _CRT_init (void);

unsigned long _DLL_InitTerm( unsigned long modhandle
                             unsigned long flag )
   {
     switch( flag )                    /* 0 == load, 1 == freed */
       {
         case 0:
           if ( _CRT_init( ) == -1 ) return 0;

           printf ("printf now works in _DLL_InitTerm(0) \n")

           break;
         case 1:
          _CRT_term ();
           break;
       }
     return 1;  /* non-zero value returned to continue load */
   }
```

- IBM C Set/2 provides a default procedure, _DLL_InitTerm, which initializes and terminates the C run-time environment.
- The user may optionally provide a modified routine if additional initialization or termination actions are required by the user DLL.

20DLLS23 930206

Types of DLL Initialization

DLL's Module Definition File

```
LIBRARY  [UTIL]   [INITGLOBAL*]  [TERMGLOBAL*]
                  [INITINSTANCE] [TERMINSTANCE]
```

* default

INITGLOBAL — Loader calls the init. routine when the 1st process attaches to the DLL. This method is good if the DLL shares resources with all processes.

INITINSTANCE — Loader calls the init. routine each time a new process attaches to the DLL. This method allocates a new set of resources for each process. Implies TERMINSTANCE.

- ✓ INITINSTANCE may be combined with 'exit lists' to allocate and deallocate resources on a per process basis.

20DLLS24 930910

Exception Management

Asynchronous/Synchronous Exceptions

Signal Exceptions

Registering Exception Handlers

Exception Management Structures

20XCPT01 920817

System Exceptions

- An exception is an abnormal condition that can occur during program execution.

- Common causes of exceptions include:
  - I/O errors
  - Protection violations
  - Math errors
  - Intervention by the user or by another process

- Activities that can cause exceptions include:
  - Invalid memory access
  - Dividing by zero
  - Pressing Ctrl+Break

20XCPT02 921009

Types of Exceptions

- Asynchronous Exceptions are caused by events that are external to the execution of the thread.
- An asynchronous exception may be caused by the user pressing Ctrl+Break or Ctrl+C, or by a process calling DosKillProcess.
- Synchronous exceptions are caused by events that are internal to the execution of the thread.
- Synchronous exceptions may be caused by:
  - Invalid memory access
  - Attempt to execute an illegal instruction
  - Math calculation errors
  - Illegal stack operation

20XCPT04 920817

Signal Exceptions

- Signal exceptions are asynchronous events sent to a thread when the user presses certain keys or when another thread or process initiates the exception.
- There are three types of signal exceptions:
  XCPT_SIGNAL_BREAK - Ctrl+Break
  XCPT_SIGNAL_INTR - Ctrl+C
  XCPT_SIGNAL_KILLPROC - DosKillProcess
- All three signals are delivered by a single exception, XCPT_SIGNAL.
- The exception handler for thread 1 can handle none, some or all of the signals
- In order for a process to receive signal exceptions when multiple processes are running in the same screen group, the process must request signal exception focus (DosSetSignalExceptionFocus).
- A process can send the XCPT_SIGNAL exception to another process (DosSendSignalException).

20XCPT05 920817

Raising Exceptions

- Asynchronous exceptions that have been deferred in a must-complete section are dispatched automatically by the system when the section is exited.
- A synchronous exception that has been deferred must be raised by DosRaiseException.
- DosRaiseException can also be used to simulate either a synchronous or an asynchronous exception.

20XCPT06 921027

Error Pop-Up Screens

- Some error conditions, such as general protection violations, cause the operating system to display a pop-up screen containing information about the error.

- The application can disable error pop-up screens.

- DosError can disable or enable both exception and hard error pop-ups.

20XCPT07 920817

Exception Handlers

- The system provides a default exception handler which, in most cases, will terminate the application.
- The application can register its own subroutine to process exceptions, allowing it to avoid termination (DosSetExceptionHandler).
- If multiple exception handlers are registered, they are invoked in Last-In-First-Out order.
- If a process termination exception occurs and exit-list procedures have have been registered, the exit-list procedure will get control after the exception handler.

20XCPT03 930910

Exception Management Data Structures

- ExceptionRegistrationRecord
  Used to establish an exception handler.

- ExceptionReportRecord
  Describes an exception.

- ContextRecord
  Describes the machine state at the time of an exception.

- DispatcherContext
  Receives information on nested exceptions and collided unwinds.

20XCPT08 920817

ExceptionRegistrationRecord

```
typedef struct _EXCEPTIONREGISTRATIONRECORD
{
  struct _EXCEPTIONREGISTRATIONRECORD * volatile prev_structure; // ptr to previous handler
  _err * volatile ExceptionHandler;                              // ptr to handler being registered
} EXCEPTIONREGISTRATIONRECORD,
  * PEXCEPTIONREGISTRATIONRECORD
```

- When a procedure begins, it must create an ExceptionRegistrationRecord on the stack, fill in the pointer to the exception handler routine, and link to the front of the exception handler chain by calling DosSetExceptionHandler.
- When the procedure ends, it must remove the ExceptionRegistrationRecord from the chain by calling DosUnsetExceptionHandler.

20XCPT09 920817

ExceptionReportRecord

```
typedef struct _EXCEPTIONREPORTRECORD
{
  ULONG  ExceptionNum;                    // exception number
  ULONG  fHandlerFlags;                   // nesting/unwinding flags
  struct _EXCEPTIONREPORTRECORD *NestedExceptionReportRecord;
                                          // ptr to nested ExceptionReportRecord
  PVOID  ExceptionAddress;                // address where exception occurred
  ULONG  cParameters;                     // number of ExceptionInfo elements
  ULONG  ExceptionInfo[4];                // exception specific info
} EXCEPTIONREPORTRECORD, *PEXCEPTIONREPORTRECORD;
```

0x0	XCPT_UNKNOWN_ACCESS
0x1	XCPT_READ_ACCESS
0x2	XCPT_WRITE_ACCESS
0x4	XCPT_EXECUTE_ACCESS
0x8	XCPT_SPACE_ACCESS
0x10	XCPT_LIMIT_ACCESS

0x1	EH_NONCONTINUABLE
0x2	EH_UNWINDING
0x4	EH_EXIT_UNWIND
0x8	EH_STACK_INVALID
0x10	EH_NESTED_CALL

0x80000001	XCPT_GUARD_PAGE_VIOLATION	0xC0000097	XCPT_FLOAT_INVALID_OPERATION
0x80010001	XCPT_UNABLE_TO_GROW_STACK	0xC0000098	XCPT_FLOAT_OVERFLOW
0xC0000005	XCPT_ACCESS_VIOLATION	0xC0000099	XCPT_FLOAT_STACK_CHECK
0xC0000006	XCPT_IN_PAGE_ERROR	0xC000009A	XCPT_FLOAT_UNDERFLOW
0xC000001C	XCPT_ILLEGAL_INSTRUCTION	0xC000009B	XCPT_INTEGER_DIVIDE_BY_ZERO
0xC000001D	XCPT_INVALID_LOCK_SEQUENCE	0xC000009C	XCPT_INTEGER_OVERFLOW
0xC0000024	XCPT_NONCONTINUABLE_EXCEPTION	0xC000009D	XCPT_PRIVILEGED_INSTRUCTION
0xC0000025	XCPT_INVALID_DISPOSITION	0xC000009E	XCPT_DATATYPE_MISALIGNMENT
0xC0000026	XCPT_UNWIND	0xC000009F	XCPT_BREAKPOINT
0xC0000027	XCPT_BAD_STACK	0xC00000A0	XCPT_SINGLE_STEP
0xC0000028	XCPT_INVALID_UNWIND_TARGET	0xC0010001	XCPT_PROCESS_TERMINATE
0xC0000093	XCPT_ARRAY_BOUNDS_EXCEEDED	0xC0010002	XCPT_ASYNC_PROCESS_TERMINATE
0xC0000094	XCPT_FLOAT_DENORMAL_OPERAND	0xC0010003	XCPT_SIGNAL
0xC0000095	XCPT_FLOAT_DIVIDE_BY_ZERO	0xC0010004	XCPT_B1NPX_ERRATA_02
0xC0000096	XCPT_FLOAT_INEXACT_RESULT		

20XCPT10 921009

ContextRecord

```
typedef struct _CONTEXT
{
   ULONG ContextFlags;
   ULONG ctx_env[7];
   FPREG  ctx_stack[8];
   ULONG ctx_SegGs;
   ULONG ctx_SegFs;
   ULONG ctx_SegEs;
   ULONG ctx_SegDs;
   ULONG ctx_RegEdi;
   ULONG ctx_RegEsi;
   ULONG ctx_RegEax;
   ULONG ctx_RegEbx;
   ULONG ctx_RegEcx;
   ULONG ctx_RegEdx;
   ULONG ctx_RegEbp;
   ULONG ctx_RegEip;
   ULONG ctx_SegCs;
   ULONG ctx_EFlags;
   ULONG ctx_RegEsp;
   ULONG ctx_SegSs;
} CONTEXTRECORD, *PCONTEXTRECORD;
```

CONTEXT_FLOATING_POINT	0x00000008L
CONTEXT_SEGMENTS	0x00000004L
CONTEXT_INTEGER	0x00000002L
CONTEXT_CONTROL	0x00000001L

20XCPT11 921009

Exception Handling Example

```
// pagefalt.c    example of page fault exception handler

#define INCL_DOS
#define INCL_DOSERRORS
#define INCL_DOSEXCEPTIONS
#include <os2.h>
#include <stdio.h>

#define STDOUT  1
#define STDERR  2

APIRET  APIENTRY  MyHandler ( PEXCEPTIONREPORTRECORD pERepRec,
                               PEXCEPTIONREGISTRATIONRECORD pERegRec,
                               PCONTEXTRECORD pCtxRec,
                               PVOID p );  // ptr to dispatcher context

void terminate ( PSZ pszMsg, APIRET rc, PSZ pszMyName );
void querymem (PCH pchStartQuery, ULONG ulLength);

void main ( void)
{
    EXCEPTIONREGISTRATIONRECORD xcpthand;
    APIRET rc;
    PSZ pszMyName = "PAGEFALT:";
    PCH  pBuf;
    ULONG ulAttr;
    ULONG ulX;

    setbuf ( stdout, NULL );

    xcpthand.prev_structure = END_OF_CHAIN;
    xcpthand.ExceptionHandler = MyHandler;

    rc = DosError ( FERR_DISABLEEXCEPTION | FERR_DISABLEHARDERR ); // disable pop-ups
    if (rc) terminate ("DosError problem\n", rc, pszMyName);

    rc =DosSetExceptionHandler ( &xcpthand );
    if (rc) terminate ("SetExceptionHandler problem\n", rc, pszMyName);

    rc = DosAllocMem ( (PVOID) &pBuf, 8192, PAG_READ | PAG_WRITE );
    if (rc) terminate ("AllocMem error\n", rc, pszMyName);

    rc = DosSetMem ( pBuf, 4096, PAG_COMMIT | PAG_DEFAULT );
    if (rc) terminate ("SetMem error\n", rc, pszMyName);

     for (ulX = 4090; ulX < 4100; ulX++)
        {
        pBuf[ulX] = '1';
        printf ("ulX = %d pBuf[ulX] = %x\n", ulX, pBuf[ulX] );
        }

    rc = DosUnsetExceptionHandler ( &xcpthand );
    if (rc) terminate ("UnsetExceptionHandler problem\n", rc, pszMyName);

    printf ("Terminating\n");

    DosExit ( EXIT_PROCESS, NO_ERROR );
}
```

20XCPT12021009

Exception Handling Example cont'd

```
APIRET  APIENTRY  MyHandler ( PEXCEPTIONREPORTRECORD pERepRec,
                              PEXCEPTIONREGISTRATIONRECORD pERegRec,
                              PCONTEXTRECORD pCtxRec,
                              PVOID p )
{
    ULONG   cbWritten, ulMemSize, flMemAttrs;
    APIRET  rc;

//  Access violation at a know location

    if ( pERepRec->ExceptionNum == XCPT_ACCESS_VIOLATION &&
         pERepRec->ExceptionAddress != (PVOID) XCPT_DATA_UNKNOWN )
    {

// page fault
      if ( ( pERepRec->ExceptionInfo[0] == XCPT_READ_ACCESS ||
             pERepRec->ExceptionInfo[0] == XCPT_WRITE_ACCESS) &&
             pERepRec->ExceptionInfo[1] != XCPT_DATA_UNKNOWN )
      {
        DosWrite ( STDERR, "\r\nHANDLER: Page Fault\r\n", 24, &cbWritten );

// now query the memory to find out why we faulted

        ulMemSize = 1;

        DosQueryMem ( (PVOID) pERepRec->ExceptionInfo[1],
                      &ulMemSize, &flMemAttrs );

// If the memory is free or committed, we have some other problem.
// If it is not free or not committed, commit it.

        if ( !(flMemAttrs & ( PAG_FREE | PAG_COMMIT )))
        {
          DosWrite ( STDERR, "\r\nHANDLER: Attempt to access "\
                     "uncommitted memory\r\n", 49, &cbWritten );

          rc = DosSetMem ( (PVOID) pERepRec->ExceptionInfo[1], 1,
                           PAG_DEFAULT | PAG_COMMIT );

          if ( rc )
          {
            DosWrite ( STDERR, "\r\nError committing memory\r\n",
                       27, &cbWritten );
            return ( XCPT_CONTINUE_SEARCH );  // not handled
          }

          else
            return ( XCPT_CONTINUE_EXECUTION );  // handled
        } // end if
      } // end if
    } // end if
    return ( XCPT_CONTINUE_SEARCH );  // not handled
}
```

20XCPT13 930619

Summary of Exception Related Functions

DosAcknowledgeSignalException
DosEnterMustComplete
DosExitMustComplete
DosRaiseException
DosSendSignalException
DosSetExceptionHandler
DosSetSignalExceptionFocus
DosUnsetExceptionHandler
DosUnwindException

20XCPT14 920818

Session Management

Session Resources

Session Management

Session Hierarchy

Session Startup

20SESN01 921009

Overview of Sessions, Processes, & Threads

- Session - A collection of one or more processes associated with a virtual console
- Process - A collection of one or more threads and associated system resources.
- Thread - A dispatchable unit of work
- Resources are distributed between Sessions, Processes, and Threads.

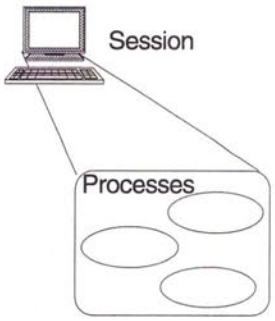
20SESN02 920814

Session Resources

- ✓ Video Buffer
- ✓ Keyboard Buffer
- ✓ Mouse Buffer
- ✓ Session ID
- ✓ Child Session

20SESN03 920814

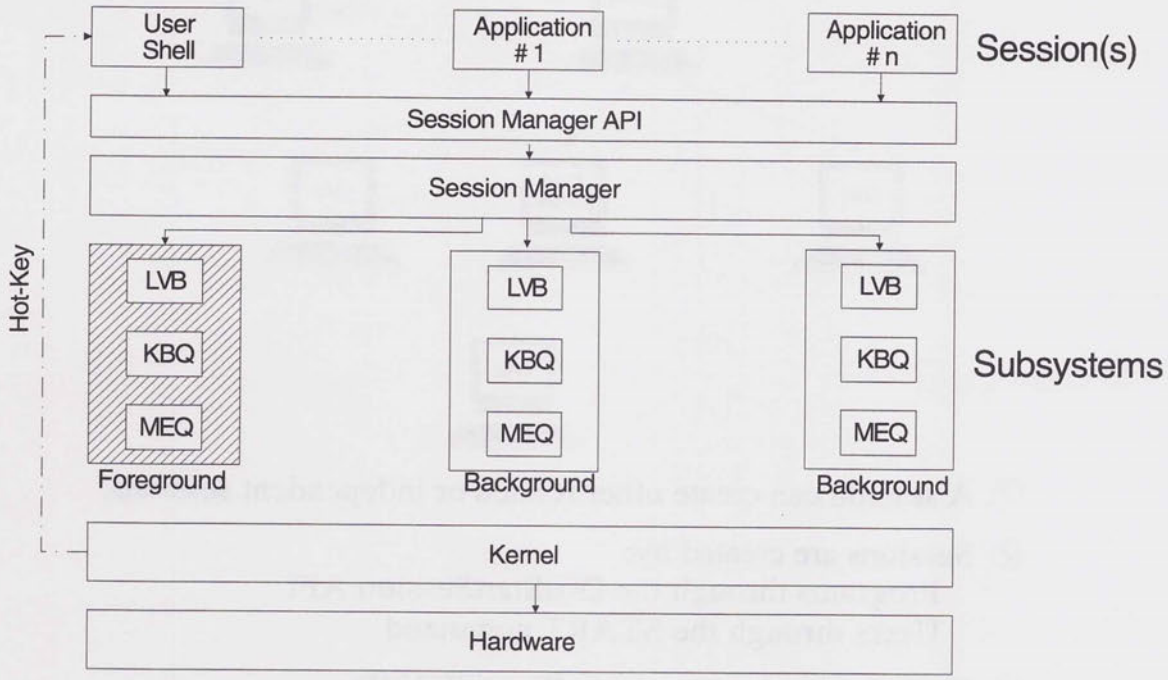
Session



- A session is one or more processes that all share the same keyboard, mouse, and display.
- A maximum of 255 sessions is permitted. Those sessions may be any mixture of Full Screen, Graphic Window, Text Window or Virtual Dos Machines.
- Each session contains at least one process.

20SESN04 921009

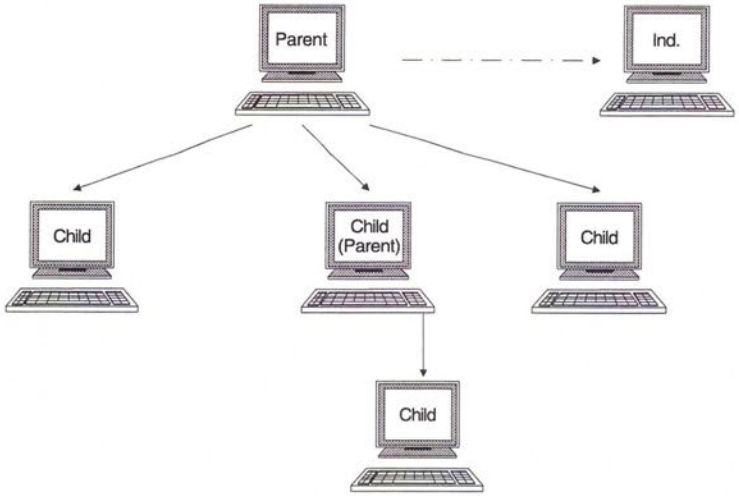
Session Management Components



- The Session Manager switches the 'focus' of the subsystem to the correct application.

20SESN05 930210

Session Hierarchy



- A session can create other related or independent sessions.
- Sessions are created by:
  - Programs through the DosStartSession API
  - Users through the START command
- Each session has a session ID # (SESSID).
- If a child session is stopped, all descendants are stopped.

20SESN06 920814

Creating A Session

- DosStartSession creates independent or dependent (child) sessions.
- A Newly created session can be started in the foreground or background.
- A Session ID and a process ID are returned to the Parent Session (valid only if Child Session).
- The process in the new session can be the command processor .
- A termination queue may be set up so that parent sessions can be notified when child sessions terminate.

20SESN07 921009

DosStartSession

```
DosStartSession (PSTARTDATA  psd,      <-- start session data
                 PULONG  pidSession,   --> returned session id
                 PPID  ppid );         --> returned process id
```

0	NO_ERROR
369	ERROR_SMG_INVALID_SESSION_ID
418	ERROR_SMG_INVALID_CALL
460	ERROR_SMG_PROCESS_NOT_PARENT
463	ERROR_SMG_RETRY_SUB_ALLOC

```
STARTDATA startdata;

startdata.Length - 24;
startdata.Related = SSF_RELATED_CHILD;
startdata.FgBg = SSF_FGBG_BACK;
startdata.TraceOpt = SSF_TRACEOPT_NONE;
startdata.PgmTitle = "Browse";
startdata.PgmName = "c:\os20labs\browse.exe";
startdata.PgmInputs = "browse\0 main.c\0\0";
startdata.TermQ = 0;

DosStartSession ( &startdata, &pidSession,
                                  &pid );
```

```
typedef struct _STARTDATA {
    USHORT  Length;
    USHORT  Related;
    USHORT  FgBg;
    USHORT  TraceOpt;
    PSZ  PgmTitle;
    PSZ  PgmName;
    PBYTE  PgmInputs;
    PBYTE  TermQ;                  24
    PBYTE  Environment;
    USHORT  InheritOpt;            30
    USHORT  SessionType;           32
    PSZ  IconFile;
    ULONG PgmHandle;
    USHORT  PgmControl;
    USHORT  InitXPos;
    USHORT  InitYPos;
    USHORT  InitXSize;
    USHORT  InitYSize;             50
    USHORT Reserved;
    PSZ  ObjectBuffer;
    ULONG  ObjectBuffLen;          60
} STARTDATA, *PSTARTDATA;
```

Setting Selectability and Bonding of a Child Session

- When a child session is selectable, the user can select it from the Window List or by using Alt+Esc.
- When a child session is nonselectable, the user CANNOT select the session.
- An application can establish a bond between a parent session and one of its child sessions.
- When the two sessions are bound, the operating system brings the child session to the foreground when the user selects the parent session.

20SESN09 920814

DosSetSession

```
DosSetSession ( ULONG  idSession,      <-- session id
                PSTATUSDATA  psd );<-- ptr to status data structure
```

```
  0 NO_ERROR
369 ERROR_SMSG_INVALID_SESSION_ID
418 ERROR_SMSG_INVALID_CALL
455 ERROR_SMSG_INVALID_BOND_OPTION
456 ERROR_SMSG_INVALID_SELECT_OPT
460 ERROR_SMSG_PROCESS_NOT_PARENT
461 ERROR_SMSG_INVALID_DATA_LENGTH
463 ERROR_SMSG_RETRY_SUB_ALLOC
```

```
typedef struct _STATUSDATA {
USHORT  Length;   /* 6 */
USHORT  SelectInd;
USHORT  BondInd;
} STATUSDATA, *PSTATUSDATA;
```

```
0 SET_SESSION_UNCHANGED
1 SET_SESSION_SELECTABLE
2 SET_SESSION_NON_SELECTABLE
1 SET_SESSION_BOND
2 SET_SESSION_NO_BOND
```

- This function may only be called by a parent session and only for a child session.
- The status of a session that was started as unrelated cannot be changed.
- When a bond is established with a child session, any bond that the parent had with another child session is broken.

```
STATUSDATA statusdata;
statusdata.length = 6
statusdata.Selected = SET_SESSION_UNCHANGED;
statusdata.BondInd = SET_SESSION_BOND;
DosSetSession ( idSession, &statusdata );
```

20SESN10 921027

DosSelectSession

DosSelectSession (ULONG idSession);

0	NO_ERROR
224	ERROR_SMG_NO_TARGET_WINDOW
369	ERROR_SMG_INVALID_SESSION_ID
418	ERROR_SMG_INVALID_CALL
459	ERROR_SMG_BAD_RESERVE
460	ERROR_SMG_PROCESS_NOT_PARENT
463	ERROR_SMG_RETRY_SUB_ALLOC

- A parent can force itself or any child session to the foreground.
- DosSelectSession only works if parent or any child is already in the foreground.
- If a child terminates while in the foreground, the parent becomes the foreground session.
- The PARENT HAS CONTROL!

20SESN11 920814

DosStopSession

DosStopSession (ULONG scope, ULONG idSession);

0	NO_ERROR
224	ERROR_SMG_NO_TARGET_WINDOW
418	ERROR_SMG_INVALID_CALL
458	ERROR_SMG_INVALID_STOP_OPTION
459	ERROR_SMG_BAD_RESERVE
460	ERROR_SMG_PROCESS_NOT_PARENT
463	ERROR_SMG_RETRY_SUB_ALLOC

0	STOP_SESSION_SPECIFIED
1	STOP_SESSION_ALL

- Can only be used by a parent session to stop one or all of its child sessions.
- If the specified child session has related sessions, the related sessions are also terminated.
- The parent session may be running in the foreground or background.
- If the child session is running in the foreground when it is terminated, the parent session becomes the foreground session.

```
DosStopSession ( STOP_SESSION_ALL, idSession );
```

20SESN12 940125

Pipes

Anonymous Pipes

Standard Input/Output

Duplicating File Handles

Named Pipes

20PIPE01 920810

Standard Input/Output

'C' Example of Using Standard Input/Output

```
/* lower.c -- converts uppercase characters to lower case */
#include <stdio.h>
#include <ctype.h>
main (int argc, char * argv[], char * envp[])
{
   char ch;
   while (( ch = getchar() ) != EOF ) // read STDIN
     putchar ( tolower ( ch ) ); // write STDOUT
}
```

- ✓ Standard devices can be redirected to other devices, files or pipes.
- ✓ A child process could inherit Standard device handles that have been redirected to pipe handles.

20PIPE03 930810

— UNAMED PIPES are half duplex

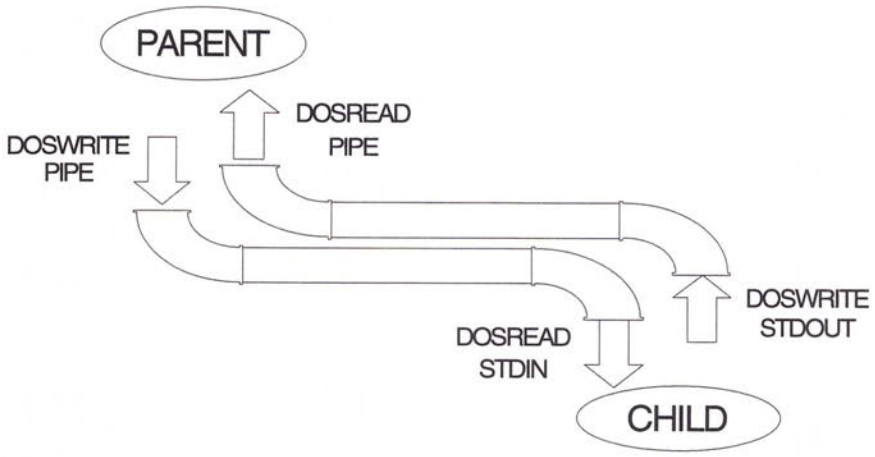
Anonymous Pipes

- A data storage buffer that OS/2 maintains.
- The maximum size of the buffer is 64 Kb.
- Similar to a file in that it is read and written via the file handle operations DosRead and DosWrite.
- Differs from a file in that the data may only be accessed in FIFO fashion.
- Since a child process inherits file handles from the parent, anonymous pipes are used to communicate between related processes.

20PIPE02 921101

NOT RANDOM ACCESS

Using Anonymous Pipes



- ✓ Two pipes must be created to provide bidirectional communication.
- ✓ Standard device handles are redirected to the pipe read/write handles with DosDupHandle.

20pipe04 920810

DosCreatePipe, DosDupHandle

```
DosCreatePipe ( PHFILE  phfRead, --> ptr to returned read handle
                PHFILE  phfWrite,--> ptr to returned write handle
                ULONG cb );      <-- size of pipe buffer
```

0 NO_ERROR
8 ERROR_NOT_ENOUGH_MEMORY

```
DosCreatePipe ( &hfRead, &hfWrite, 1024 );
```

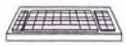
```
DosDupHandle ( HFILE  hFile,     <-- handle to be duplicated
               PHFILE  phFile ); <--> ptr to duplicate
```

0 NO_ERROR
4 ERROR_TOO_MANY_OPEN_FILES
6 ERROR_INVALID_HANDLE
114 ERROR_INVALID_TARGET_HANDLE

```
HFILE hNewHandle = STDIN;
DosDupHandle ( hfRead, &hNewHandle );
```

20PIPE05 921021

Pipes/Redirection Example

STDIN(0)	STDOUT(1)	STDERR(2)	Handle 6	Handle 7	Handle 8	
	CON	CON	X	X	X	Start
"	"	"	Rpipe	Wpipe	X	CreatePipe
"	"	"	"	"		DupHandle (0, &-1)
Rpipe	"	"	"	"	"	DupHandle (6, &0)
"	"	"	No Inherit	No Inherit	No Inherit	DosSetFHState ()
"	"	"	"	"	"	ExecPgm
	"	"	"	"	"	DupHandle (8, &0)
"	"	"	"	"	X	DosClose (8)
"	"	"	"	"	"	DosWrite (7) parent
Rpipe	CON	CON				*DosRead (STDIN) child*

20PIPE06 921027

— Example of setting up a child's STDIN(0) as Parent's STDOUT(1)

Named Pipes

- Like anonymous pipes, they provide serial communication between two processes.
- Users of the named pipe need not be related.
- Named pipes can be used in byte-stream or message mode.
- Named pipes may be full duplex. A single handle is used for both reading and writing.
- Named pipes work both locally on a single system and remotely across a network.
- DOS workstations may communicate with an OS/2 server through named pipes.

20PIPE06 920810

Server/Client Communication Using Named Pipes

- The server process creates the pipe by calling DosCreateNPipe. The pipe is now 'disconnected' and cannot be opened by a client process.
- The server process calls DosConnectNPipe to put the pipe into the 'listening' mode.
- A client process supplies the name of the pipe in a call to DosOpen and receives a pipe handle. The pipe is now in the 'connected' state.
- The server and client process communicate by calling DosRead, DosWrite or DosTransactNPipe.
- The client process calls DosClose to close its end of the pipe. The pipe is now in the 'closing' state and cannot be accessed by another client.
- The server process calls DosDisconnectNPipe. The pipe is now in the 'disconnected' state again.
- To enable another client, the server must call DosConnectNPipe again.

20PIPE08 921124

Named Pipe Server Program Example

```
// example multi-thread server program for Named Pipes   pipeserv.c

#define INCL_BASE
#include <os2.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <malloc.h>

#define PIPE_NAME          "\\pipe\\example"
#define LOWER_CASE_OFFSET  ('a' - 'A')
#define STDOUT             1

HEV     server_sem = 0;
USHORT  connection_id = 0;
HPIPE   pipe_handle;
BOOL    flContinue = TRUE;

// internal functions
void thread (void);

// external functions
void terminate ( PSZ pszMsg, APIRET rc, PSZ pszMyName);

int main ( void )
{
    TID     thread_id;
    PSZ     pszMyName = "PIPESERV:";
    APIRET  rc;

    while ( flContinue )
    {
// create an instance of the named pipe
        rc = DosCreateNPipe ( PIPE_NAME, &pipe_handle, NP_ACCESS_DUPLEX,
                              NP_WAIT | NP_READMODE_MESSAGE |
                              NP_TYPE_MESSAGE | NP_UNLIMITED_INSTANCES,
                              128, 128, 0 );
        if (rc) terminate ("Error Creating Pipe\n", rc, pszMyName);

        DosEnterCritSec ();
        printf ("%s Pipe Instance Created. Waiting for a "\
                "connection...\n", pszMyName);
        DosExitCritSec ();

// put pipe in 'listening' mode and wait for a connection
        rc = DosConnectNPipe ( pipe_handle );
        if (rc) terminate ("Error Connecting Pipe\n", rc, pszMyName);
        printf ("%s Connection Received\n", pszMyName);

// create event sema4. Server thread will post when it starts
        rc = DosCreateEventSem ( 0, &server_sem, 0, FALSE );
        if (rc) terminate ("Error Creating EventSem\n", rc, pszMyName);

// create a server thread
        rc = DosCreateThread ( &thread_id, (PFNTHREAD) thread, 0, 0, 8192 );
        if (rc) terminate ("Error Creating Server Thread\n", rc, pszMyName);
        printf ("%s Server Thread Created\n", pszMyName);

// wait for signal that thread is running
        rc = DosWaitEventSem ( server_sem, 1000 );
        if (rc) terminate ("Error waiting for thread sema4\n", rc, pszMyName);
    }   // end while

    return 0;
}
```

20PIPE09 921129

Named Pipe Server Program Example cont'd

```
// thread to manage a server connection          pipeserv.c
void thread ( void )
{
    APIRET  rc;
    USHORT  my_connection;
    HPIPE   hPipe;
    BOOL    keep_connection = TRUE;
    CHAR    buffer[128];
    ULONG   bytes_read;
    USHORT  index = 0;
    ULONG   bytes_written;
    PSZ     pszMyName = "SERVTHRD:";

// bump the connection count
    connection_id += 1;

// get my connection id
    my_connection = connection_id;

// get my pipe handle
    hPipe = pipe_handle;

// signal the main thread so it can continue
    printf ("%s Connection #%d\n", pszMyName, my_connection);
    DosPostEventSem ( server_sem );

    while ( keep_connection )
    {
// read a message from the pipe
        rc = DosRead ( hPipe, buffer, 128, &bytes_read );
        if (rc)
        {
          keep_connection = FALSE;
          break;
        }
// print message
        DosEnterCritSec ();
        printf ("%s%d Message received: %s\n",
                 pszMyName, my_connection, buffer );
        DosExitCritSec ();

// process and write it back
        while ( index < strlen (buffer) )
        {
            if (( buffer[index] >= 'a' ) && ( buffer[index] <= 'Z'))
                buffer[index] -= LOWER_CASE_OFFSET;
            index += 1;
        } // end while

        rc = DosWrite (hPipe, buffer, strlen (buffer), &bytes_written );
        if (rc) terminate ("Error Writing Pipe\n", rc, pszMyName);

// if 'done', drop thru and disconnect
        keep_connection = (stricmp (buffer, "done") != 0 );
    } // end while


// disconnect and close the pipe
    rc = DosDisConnectNPipe ( hPipe );
    if (rc) terminate ("Error Disconnecting Pipe\n", rc, pszMyName);
    printf ("%s%d Disconnecting\n", pszMyName, my_connection);

// close the pipe
    rc = DosClose ( hPipe );
    if (rc) terminate ("Error Closing Pipe\n", rc, pszMyName);

// exit the thread
    DosExit ( EXIT_THREAD, 0);
}
```

20PIPE10 921129

Named Pipe Client Program Example

```
// example client program for Named Pipes
// pipeclnt.c
#define INCL_BASE
#include <os2.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#define STDOUT      1

// external functions
void terminate ( PSZ pszMsg, APIRET rc, PSZ pszMyName);

int main ( void )
{
    APIRET  rc = 0;
    HPIPE   pipe;
    ULONG   action;
    CHAR    pipe_name[61];
    CHAR    input[64];
    PSZ     pszMyName = "PIPECLNT:";
    CHAR    result[64];
    ULONG   bytes_returned;

// get name server. If no server name entered, connect locally

    printf ("Enter the server name or <Enter>: \n");
    gets (input);

    if (input[0] != '\0' )
      {
          strcpy (pipe_name, "\\\\");
          strcat (pipe_name, input);
          strcat (pipe_name, "\\pipe\\example");
      }
      else
          strcpy(pipe_name, "\\pipe\\example");

// wait for available instance of pipe

    rc = DosWaitNPipe ( pipe_name, SEM_INDEFINITE_WAIT );
    if (rc) terminate ("Error waiting for pipe instance\n",
                       rc, pszMyName);
    printf ("%s Pipe Available\n", pszMyName);

    rc = DosOpen ( pipe_name, &pipe, &action, 0, 0,
                   OPEN_ACTION_OPEN_IF_EXISTS,
                   OPEN_ACCESS_READWRITE | OPEN_SHARE_DENYREADWRITE |
                   OPEN_FLAGS_WRITE_THROUGH, 0 );
    if (rc) terminate ("Error opening pipe\n", rc, pszMyName);

    printf ("%s Pipe Opened\n", pszMyName);

    rc = DosSetNPHState ( pipe, NP_READMODE_MESSAGE );  // chg. mode
    if (rc) terminate ("Error changing Pipe Mode\n", rc, pszMyName);

    printf ("%s Pipe Mode Changed\n", pszMyName);

    while ( stricmp ( input, "done" ) != 0 )
    {
      printf ("Enter string to transmit:\n");
      gets ( input );

      rc = DosTransactNPipe ( pipe, input, strlen (input) +1, result,
                              64, &bytes_returned );
      if (rc) terminate ("Error in TransactNPipe\n", rc, pszMyName);

      result[bytes_returned] = '\0';

      printf ("Result: %s\n", result );
    }
    rc = DosClose ( pipe );
    if (rc) terminate ("Error Closing Pipe\n", rc, pszMyName);

    printf ("%s Closing the Pipe\n", pszMyName);
    return 0;
}
```

20PIPE11 921208

Summary of Named Pipe Functions

DosCallNPipe
DosConnectNPipe
DosCreateNPipe
DosDisConnectNPipe
DosPeekNPipe
DosQueryNPHState
DosQueryNPipeInfo
DosQueryNPipeSemState
DosSetNPHState
DosSetNPipeSem
DosTransactNPipe
DosWaitNPipe

20PIPE12 921129

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